MARYLAND PORT ADMINISTRATION

FEASIBILITY EVALUATION

OF

BETHLEHEM STEEL SHORELINE ENHANCEMENT PROJECT

November 1992

GAHAGAN & BRYANT ASSOCIATES
111 Market Street, Suite 1001
Baltimore, MD 21202 - 4012

In Association With:

EARTH ENGINEERING & SCIENCES, INC.
ENVIRONMENTAL CONCERN, INC.

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SUMMARY

The Maryland Port Administration (MPA) is evaluating the feasibility of environmentally and visually enhancing the shoreline in front of the Bethlehem Steel Corporation plant at Sparrows Point, by developing a tidal wetland and an upland buffer.

This report presents a preliminary evaluation of the technical feasibility and estimated cost of:

- Constructing a stable dike at the Sparrows Point site in order to contain the wetlands,
- Construction of an upland buffer of approximately 33 acres to screen the industrial activities along the shoreline,
- Establish a 300 acre tidal wetland constructed with fine grained maintenance materials.

THE WETLAND CONTAINMENT DIKE

The water off of Sparrows Point is 10 to 15 feet deep. To construct a tidal wetland, material will have to be placed to raise the elevation to between +0.55 ft and +1.1 ft MLW (See Appendix B). In order to contain this material, a dike must first be built to contain the material being placed.

The construction of a stable dike is complicated by the relatively soft foundation of silts and clays in the Patapsco River bed underlying the site.

Four new borings were taken, and the samples of the material were obtained and analyzed to assist in the determination of the approximate dike cross sections, types of material to be used to construct the dike, and the ultimate elevation of the dike.

The five dike configurations considered were:

- Sand dike on a sand subdike
- Oyster shell dike on a sand subdike
- Sheet pile wall and sand dike on a sand subdike
- Oyster shell dike only
- Lightweight slag dike only

Due to the soft foundation of silts and clays in the Patapsco River bed underlying the site, all configurations were considered using a geotextile base under the fill material.

During construction, the dike is to be built in stages to insure the soft foundations are not over-stressed. Due to these soft foundations, the final elevation is not to exceed +4 ft MLW. Areas of concern during construction and afterwards include:

- There will most likely be "a mudwave" created adjacent to the dike during construction due to localized subsurface failures from over-stressing of the foundation during construction. This can be minimized by the careful monitoring and control of the filling operation, but most likely will not be eliminated.

- The elevation limitation of the dike of +4' MLW will mean that the dike will be overtopped when storm conditions raise the sea's state above that elevation. This could cause dispersal of the material placed in the site into the surrounding harbor. The effects of dispersal have not been analyzed. Consequently, the entire dike from -6 ft MLW outside the dike, across the top of the dike to 0 ft MLW must be protected from erosion by over topping during storms.

- After construction the dike will continue settling, and there will be an annual maintenance cost to maintain the dike elevation at +4 ft MLW.

Additional field data and interpretation will be required before a definitive determination and final design can be made.

Taking all the above into consideration, the results of our investigation are that a dike can be built if a geotextile material is used. Construction time will be approximately one year.

THE UPLAND BUFFER AREA

The project also includes the construction of an upland buffer area to act as a screen for shoreline industrial activity. The entire buffer can be built using dredged materials. The buffer will encompass an area of approximately 33 acres and will have a top elevation of +40 feet. The upland buffer will be built in stages and will have two components, a perimeter dike and a containment area. A low perimeter dike is constructed first and the contained area is then filled in annual lifts of approximately three feet. As the material dries and shrinks, the contained material is used to further raise the perimeter dike and successive lifts are added to the contained area. The volume of the perimeter dike is approximately 400,000 cubic yards. The volume inside the containment area is one million cubic yards. With proper placement and crust management of the material placed, 2.6 million cubic yards can be deposited in the upland buffer.

It will take approximately 16 years to build the buffer area utilizing dredged material from annual maintenance programs. Optionally, this upland buffer can be constructed more quickly using onsite or imported fill material. If this is done however, there will be less capacity for dredged material resulting in a higher unit cost of containment volume.

THE TIDAL WETLAND

Preliminary indications are that a successful tidal wetland can be established in the completed cell using clean material from annual maintenance dredging of the Baltimore Harbor navigation channels. However, a permanent dike must be constructed to provide continuous protection from wave attack. After the wetlands are constructed, this dike must have channels or openings that function as tidal creeks allowing the site to be periodically flooded and positively drained to assure plant productivity.

There will be approximately 300 acres of wetland developed requiring 7.7 million cubic yards of dredge maintenance material. Due to settlement of the subsurface material and the rate of filling from the Baltimore Harbor maintenance dredging program, it will take 12 years before the material reaches MLW and wetland construction can begin. The soils at the site must be consolidated and drained prior to planting to prevent plant mortality due to anoxia. Additionally, a sediment maintenance program is necessary to counteract settling as there is no natural sediment source at the site. Periodic replenishment of site with dredged material will be required as long-term settlement of material in the cell takes place. The PCDDF plot, figure 8, gives an indication of this. The interval between replenishment will increase with time.

Saltmarsh cordgrass (Spartina alterniflora) and salt hay (Spartina patens) are the most effective and thoroughly tested plants used in wetland creation and can be used to establish the low and high tidal wetlands, respectively, at the Bethlehem Steel Site. The use of pot grown seedlings in conjunction with direct seeding may provide the best success rate for the cost of construction. For a 300 acre site to be seeded and planted, approximately 65,340,000 live seeds and 1,600,000 potted plants will be needed. With an amount this great, an order must be placed to various nurseries a year or more in advance. A natural tidal wetland in the vicinity of the site, such as Black Marsh near North Point, is the best model to follow in determining which other plant species may be used as well as their biological benchmarks. This information should not be collected until wetland establishment, in order to ensure maximum compatibility.

SCHEDULE FOR DEVELOPMENT

The schedule for developing the project is short due to the proposed completion date of June, 1994. In order to meet this deadline, a design and detailed foundation investigation must be started by December 1, 1992. A minimum of one year construction period is required. It will take 12 years to complete the wetlands and 16 years to complete the upland buffer dike using only dredged materials. The site will accommodate 10,300,000 CY of dredged material measured in the cut. That is, measured in-situ in the channel.

PROJECT COST

Based upon the limited evaluations made for this report the estimated first or capital cost of developing the project and the annual operating, maintenance and monitoring costs during the 16 year filling period are shown below. A lesser annual maintenance will be required after development of the wetland. A detailed economic analysis including present worth analyses of the future costs of operating and maintaining site has not been prepared.

PROJECT COST - 1992 DOLLARS
(Thousands of Dollars)

	Construction	Operation & Maintenance	Total $	Unit Rate ($/cy)
1. Sand on Sand	22,900	10,400	33,300	3.23
2. Oyster Shell on Sand	24,500	10,400	34,900	3.39
3. Sheet pile on Sand	22,600	10,400	33,000	3.20
4. Oyster Shell	29,200	10,400	39,600	3.84
5. Lightweight Slag	29,600	10,400	40,000	3.88

INTRODUCTION

This report is prepared by Gahagan & Bryant Associates, Inc. (GBA) in association with Earth Engineering & Sciences, Inc. (E2Si) and Environmental Concern, Inc. (ECI). It presents an evaluation of the technical feasibility and cost of enhancing the shoreline in front of the Bethlehem Steel Corporation Plant at Sparrows Point, by constructing a tidal wetland and a shoreline buffer using maintenance materials dredged from the Outer Harbor Channels of the Port of Baltimore.

The evaluation focuses on a preliminary examination of the technical and economic feasibility of three principal aspects of the proposal:

- Construction of a wetland containment dike on the soft foundation materials present at the site
- Construction of an upland buffer of approximately 33 acres to screen the industrial activities along the shoreline
- Establishing a 300 acre tidal wetland constructed with fine-grained maintenance materials

The construction of a stable dike is complicated by the relatively soft foundation of silts and clays in the Patapsco River bed underling the site. Field and laboratory investigation of samples from four new borings made for this work and analysis of five alternative dike cross sections result in a preliminary indication that a stable dike can be built. Additional field data and investigations will be required before a definitive determination and final design can be made. The five dike configurations considered were:

- Sand Dike on a Sand Subdike
- Oyster Shell Dike on a Sand Subdike
- Sheet Pile Wall and Sand Dike on a Sand Subdike
- Oyster Shell Dike only
- Lightweight Slag Dike only

This study addresses the major factors involved in the feasibility of the construction of the dike and wetland aspects of the Shoreline Enhancement Project. The major factors analyzed are:

1. Project Site Description

2. Constructability of the Wetland Containment Dike

    - Analysis of Existing Foundations
    - Wilmington, Delaware Dike
    - Dike Dimensions (cross sections)
    - Dike Material Sources
    - Methods of Construction
    - Construction Time

3. Wetland Development

    - Elevations
    - Tidal Variation and Water Circulation
    - Sources of Materials
    - Wave Protection
    - Methods of Construction
    - Construction Time

4. Upland Buffer Area

    - Elevations
    - Sources of Material
    - Methods of Construction
    - Construction Time

5. Site Operational Considerations

    - Spillways
    - Dredged Material Placement Procedures
    - Cell Material Consolidation

6. Project Implementation Schedule

7. Project Development Costs

    - Construction Costs
    - Operation and Maintenance Costs
    - Site Capacity Costs

1.0 PROJECT SITE DESCRIPTION

The study area is located on the Southerly shore of the Sparrows Point Plant of the Bethlehem Steel Corporation along the Patapsco River in Baltimore County Maryland. The proposed wetland development area is bounded by the Brewerton Channel and the Ore Pier and Pennwood Channels (Figure 1).

The site evaluated is defined on Figure 2. To minimize the effect on the present hydraulic flow, the riverward dike limit used in this study is set by a line connecting North Point and the Southwesterly point of the Bethlehem Steel property (Sparrows Point). The site has two principal components: a wetland cell and an upland buffer area.

The containment dike and wetland cell are bounded by a line extending from the shore approximately 600 feet East of the Ore Loading Pier to a point about 2,000 feet off the shoreline, then generally paralleling the shoreline approximately 5,200 feet to a point approximately 300 feet West of the Pennwood Channel, then returning to the shoreline about 2,600 feet. The cell area within this boundary is approximately 300 acres. A hydrographic survey of the cell area was made May 2, 1991 by the Maryland Port Administration, Division of Engineering.

The upland buffer area will act as a screen for the industrial property located along the shoreline. The buffer area is located along the shoreline on an approximately 300 feet by 5,000 feet strip. The buffer area contains about 33 acres. A topographic survey of the shoreline area was prepared for the Maryland Environmental Service based upon photography taken May 25, 1991.

A tabulation of the principal characteristics of the project elements is contained in Table 1-1.

TABLE 1-1
PRINCIPAL PROJECT CHARACTERISTICS

UPLAND BUFFER AREA

Existing ground elevation varies from		+5 to +23
Average existing ground elevation is		+15
Series of stepped dikes		
Height of dikes: in 3 to 5 ft increments up to +42	Final Fill:	+40
Crown Width		8 ft
Side Slopes		1:3
Perimeter of Dike		9,800 ft

TABLE 1-1
PRINCIPAL PROJECT CHARACTERISTICS
(Continued)

Area enclosed by dike at elevation +15	33 ac
Area enclosed by dike at elevation +40	16 ac
Average area enclosed by dike	24 ac
Volume below elevation +40 contained by dike	1.0 Mcy
Plus dike material of 0.4 Mcy = Total Volume	1.4 Mcy
Capacity w/ allowance for shrinkage through crust management	2.6 Mcy
First year filling 4 ft lift	215,000 cy
Last year filling	105,000 cy
Average filling rate (3 ft lift)	160,000 cy/year

Filling Schedule 2.6 Mcy / 160,000 cy/year = 16 years

WETLAND - MAIN CELL

Average existing bottom elevation	-14
Height of dike	+4
Average Fill elevation after initial filling	+3.1
Crown width	16 ft
Side Slopes	1:3
Perimeter of dike	9,900 ft
Area enclosed by dike at elevation +2	300 ac
Cell volume below elevation +2	7.7 Mcy
Capacity, cut cy	7.7 Mcy
Average filling rate	640,000 cy/year

Filling Schedule 7.7 Mcy / 640,000 cy/year = 12 years

Total cut volume placed at site per year (a greater inflow may be possible)	800,000 cy*

* Source: MPA Dredging Needs and Placement Options Program (October 1992)

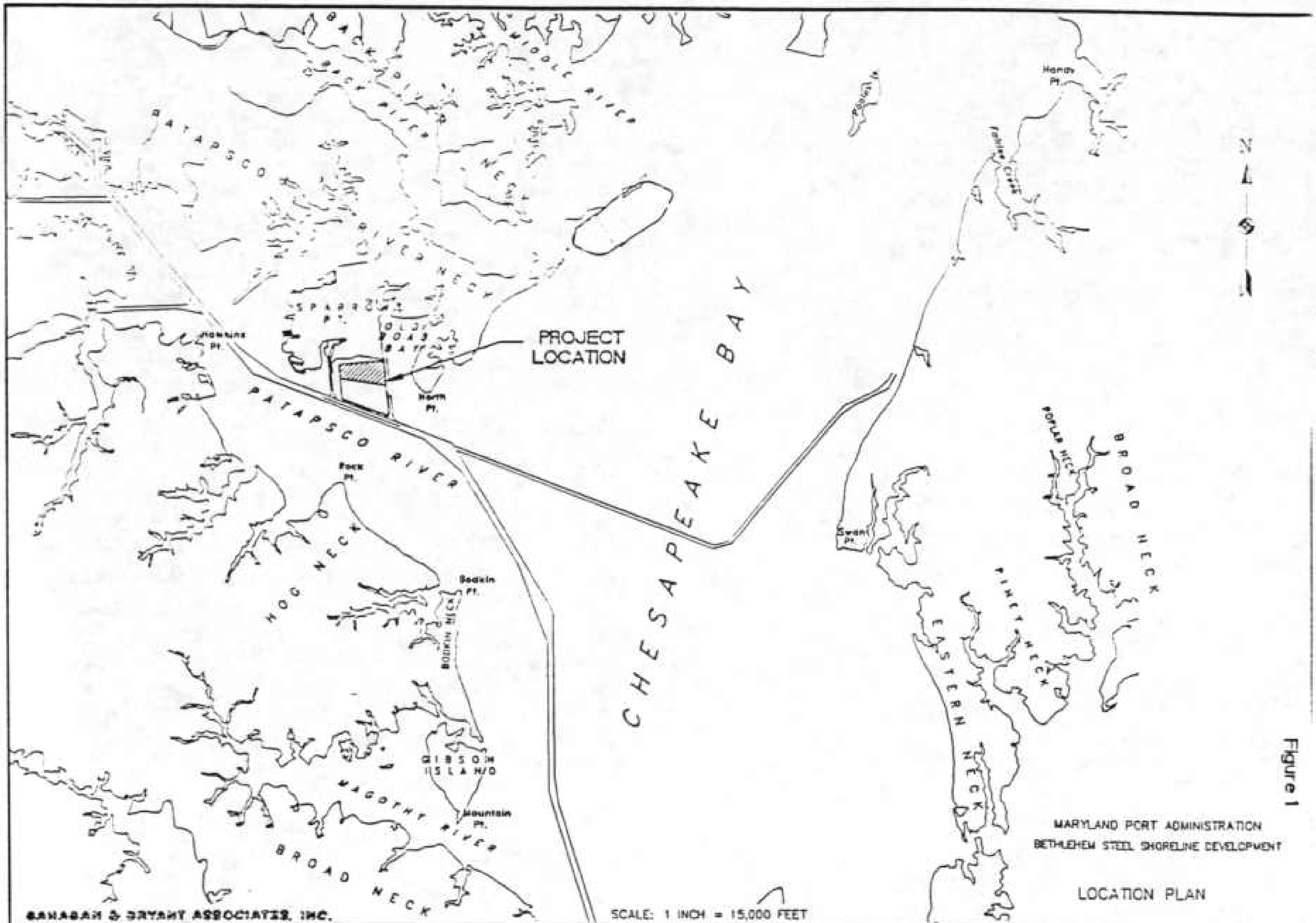
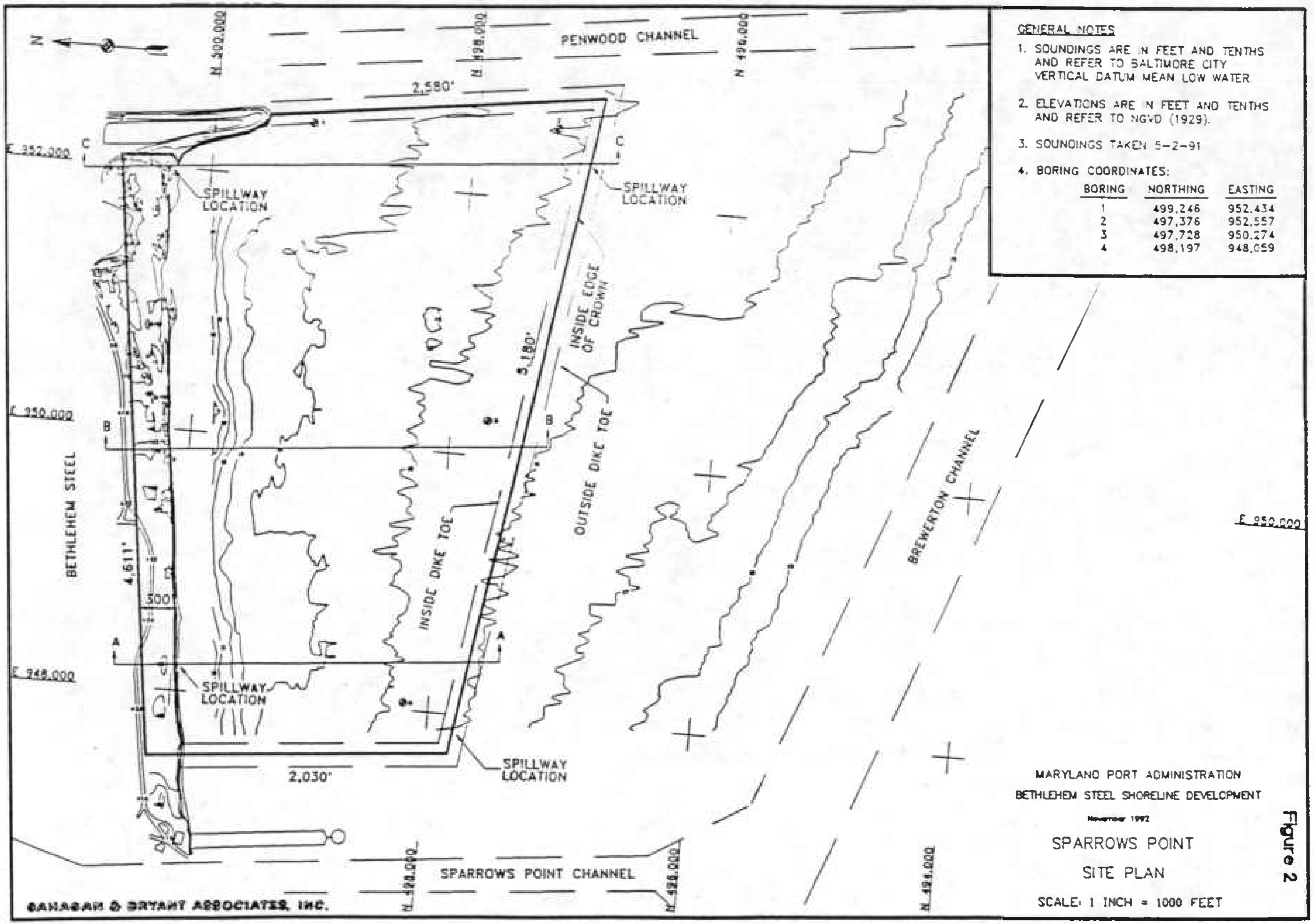

PROJECT LOCATION
CHESAPEAKE BAY
PATAPSCO RIVER
PATAPSCO RIVER NECK
BACK RIVER
BACK RIVER NECK
MIDDLE RIVER
SPARROWS PT.
OLD ROADS BAY
Hawkins Pt.
North Pt.
Rock Pt.
HOG NECK
Bodkin Pt.
BODKIN NECK
GIBSON ISLAND
Mountain Pt.
MAGOTHY RIVER
BROAD NECK
Swan Pt.
EASTERN NECK
PINEY NECK
POPLAR NECK
BROAD NECK
Hands Pt.
MARYLAND PORT ADMINISTRATION
BETHLEHEM STEEL SHORELINE DEVELOPMENT
LOCATION PLAN
SCALE: 1 INCH = 15,000 FEET
GAHAGAN & BRYANT ASSOCIATES, INC.

Figure 1


GENERAL NOTES
1. SOUNDINGS ARE IN FEET AND TENTHS AND REFER TO BALTIMORE CITY VERTICAL DATUM MEAN LOW WATER
2. ELEVATIONS ARE IN FEET AND TENTHS AND REFER TO NGVD (1929).
3. SOUNDINGS TAKEN 5-2-91
4. BORING COORDINATES:

BORING	NORTHING	EASTING
1	499,246	952,434
2	497,376	952,557
3	497,728	950,274
4	498,197	948,059

PENWOOD CHANNEL
N 500,000
N 498,000
N 496,000
2,580'
E 952,000
E 950,000
E 948,000
SPILLWAY LOCATION
INSIDE EDGE OF CROWN
5,180'
OUTSIDE DIKE TOE
INSIDE DIKE TOE
BETHLEHEM STEEL
4,611'
300'
2,030'
BREWERTON CHANNEL
SPARROWS POINT CHANNEL
N 490,000
N 496,000
N 494,000
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MARYLAND PORT ADMINISTRATION
BETHLEHEM STEEL SHORELINE DEVELOPMENT
November 1992
SPARROWS POINT
SITE PLAN
SCALE: 1 INCH = 1000 FEET

Figure 2

2.0 CONSTRUCTABILITY OF THE WETLAND CONTAINMENT DIKE

2.1 ANALYSIS OF EXISTING FOUNDATION

The geotechnical report prepared by Earth Engineering and Science, Inc. (E2Si) is contained in Appendix A. A brief summary of the field and laboratory investigations is given below.

2.1.1 Borings

Four borings were taken along the cell boundary during October 15-21, 1992. Locations are indicated on Figure 2. The borings indicate soft materials overlying hard material to depths of 10 and 20 feet along the Pennwood Channel. Borings along the Brewerton Channel and Ore Pier Channel boundaries of the cell have soft materials to at least 70 feet, the limit of the borings. The upper 30 feet of the soft foundation materials have shear strengths on the order of 100 to 300 pounds per square feet.

2.1.2 Field and Laboratory Testing

Field testing consisted of standard penetration tests in each boring at intervals of 2 to 5 feet and ten vane shear tests in the soft materials at the four borings. A summary of the results of field and laboratory tests is contained below in Table 2-1.

TABLE 2-1
SUMMARY OF FIELD AND LABORATORY TESTS
(Data for Soft, Gray Silty Clay)

Density	90 pcf
Water Content	80 - 130 %
Liquid Limit	100 - 200
Plastic Limit	35 - 40
Cohesion	100 - 600 psf

Shear Strength and Friction Angle with Depth

-15 to -35 ft	100 psf	0 degrees
-35 to -45 ft	200	0
below -45 ft	300	0

Source: E2Si, Preliminary Subsurface Investigation (November 1992)

2.2 WILMINGTON, DELAWARE DIKE

During 1986 through March 1990, a 260 acre disposal area enclosed on three sides by a dike about 8,000 feet in length was constructed at the Port of Wilmington, Delaware for the Philadelphia District Corps of Engineers. The dike was constructed upon a geotextile in two stages: stage 1 to about elevation +4 feet; and stage 2 to elevation +15 feet. Wick drains were installed to induce about 4 feet of settlement in the stage 1 fill over a 12 month period. Foundation strengths of the soft foundation materials vary from 100 to 150 pounds per square feet (psf) in the top 40 feet. Large mud waves were experienced during the construction.

The conditions and size of the disposal area are comparable to the proposed Bethlehem Steel site except that water depths at Wilmington reached 30 feet and the tidal range is about 6 feet. The cost of construction was about $25 million.

2.3 DIKE DIMENSIONS

2.3.1 Containment Dike Options Considered

Two types of sections: a "Full Section" and a "Composite Section" have been evaluated for this project. All sections have a geotextile over the foundation. All dike tops are at elevation +4 feet Mean Low Water (MLW) and are designed to be overtopped by high tides and wave wash.

The "Full Section" is a simple trapezoid section built of lightweight materials or sand. The lightweight material is either processed oyster shell or slag with an estimated unit weight of 75 pounds per cubic feet (pcf) for shell and 85 pcf for slag. The "Composite Section" consists of a 200 feet wide sand berm to elevation -6 feet MLW using lightweight material or sand and built in two lifts of about 5 feet each. A third variation of the composite section is the use of a steel sheet piling wall driven into the sand berm. The purpose of all these sections is to provide a low stress in the soft foundation soils at the site.

Rip rap slope protection is provided for all sections from elevation -6 ft MLW outside the cell across the top of the dike and to elevation 0 ft MLW inside the cell.

Typical cross sections of the five options considered are presented in Figures 3 through 8. The total volumes required for the five sections varies from 0.7 to 1.2 million cubic yards (mcy) as indicated in Table 2-2, and are based on the following assumptions:

- All "Case" numbers refer to the alternatives established by E2Si
- All template volumes are based on E2Si sketches
- Dike volumes include an allowance for 3' of displacement during initial dike installation
- All quantities are based on an assumed average depth of water of 15' MLW
- 9900 linear feet was used as the dike length

To obtain the quantity of material needed to meet the required template quantities, additional material must be dredged or obtained to compensate for the inherent losses in the dredging process to get the in situ material from cut to fill; over build allowance for run off and shrinkage; and displacement due to settlement.

TABLE 2-2
MATERIAL QUANTITIES
(Thousands of Cubic Yards)

	Required Template	Loss Cut To Fill	Over-build	Displace-ment	Total
1 - Sand on Sand	668	167	167	229	1,231
2 - Shell on Sand					
Sand	568	142	142	229	1,081
Shell	100		25		125
Subtotal	668	142	167	229	1,206
3 - Sheet pile on Sand	435	109	109	176	829
4 - Oyster Shell	440		88	143	671
5 - Slag	440		88	143	671

2.4 DIKE MATERIAL SOURCES

Three materials have been considered for the dike section as described below.

2.4.1 Sand

The sand source considered for this study is the Craighill Channel. It is assumed that mining in the channel will continue to be allowed. Medium to fine grained sand was obtained from the Craighill Channel as backfill for the Fort McHenry Tunnel and for the raising of the Hart Miller Island dike.

Other sand sources that may be considered are Hart Miller Island and material excavated from cells at the Baltimore City Quarantine Road landfill. The availability, permitability and cost of these sources as well as the Craighill Channel sand must be determined in detail, as part of further design studies.

2.4.2 Slag

Lightweight processed slag is available at the Sparrows Point plant under a proprietary operation. The price and market factors involved in the use of this material must also be further refined as part of design studies. Cost estimates contained in this report are based on verbal quotes from the supplier.

2.4.3 Oyster Shell

Oyster shell is mined under license from the Department of Natural Resources. Some material may be available for use on this project. As with all the dike materials given consideration, it will be necessary to determine the feasibility of use of this material in much greater detail. Cost estimates contained in this report are based upon verbal quotes from the supplier.

2.5 METHODS OF CONSTRUCTION

Dike construction methods for the three dike materials considered; sand, oyster shell and slag, and rock rip rap are discussed below. All sand methods below utilize material from the Craighill Channel. Other possible sand sources include Hart Miller Island and the Quarantine Road landfill cell excavation. These sand sources have not been evaluated.

2.5.1 Sand, Method 1

Method 1 employs a 27-inch hydraulic dredge with a spider barge loading sand into hopper scows at the Craighill Channel. Hopper scows will be towed to the project site and unloaded by a hydraulic barge unloader.

2.5.2 Sand, Method 2

In Method 2, a 27-inch hydraulic dredge is used to pump directly from the Craighill Channel to the project site. The pumping distance is approximately 42,000 feet. A booster pump would be used in the pipeline.

2.5.3 Sand, Method 3

Method 3 employs a 21 cubic yard clamshell dredge loading hopper scows towed to the project site. Scows will be unloaded by a hydraulic barge unloader.

2.5.4 Sand, Method 4

Method 4 employs a hopper dredge to dredge material from the Craighill Channel. The dredge will travel to the project site and pumpout to the dike.

2.5.5 Sand Placement

All sand methods described in paragraphs 2.5.1 through 2.5.4 involve the same placement method. The hydraulic placement of sand into the dike section will be accomplished by the use of a spreader barge. The barge will be held in position by anchors and winches and will have electronic systems to control the placement of the sand.

2.5.6 Oyster Shell

It is assumed that a permit is issued to dredge Oyster Shell from the Chesapeake Bay. The material will be delivered on barges. Shell material in the dike base (estimated below elevation -6 MLW) will be "washed" off the deck of the barge through a distributor to provide uniform buildup of the dike section. Above elevation -6 MLW shell material will be unloaded and placed with a clamshell bucket.

2.5.7 Slag

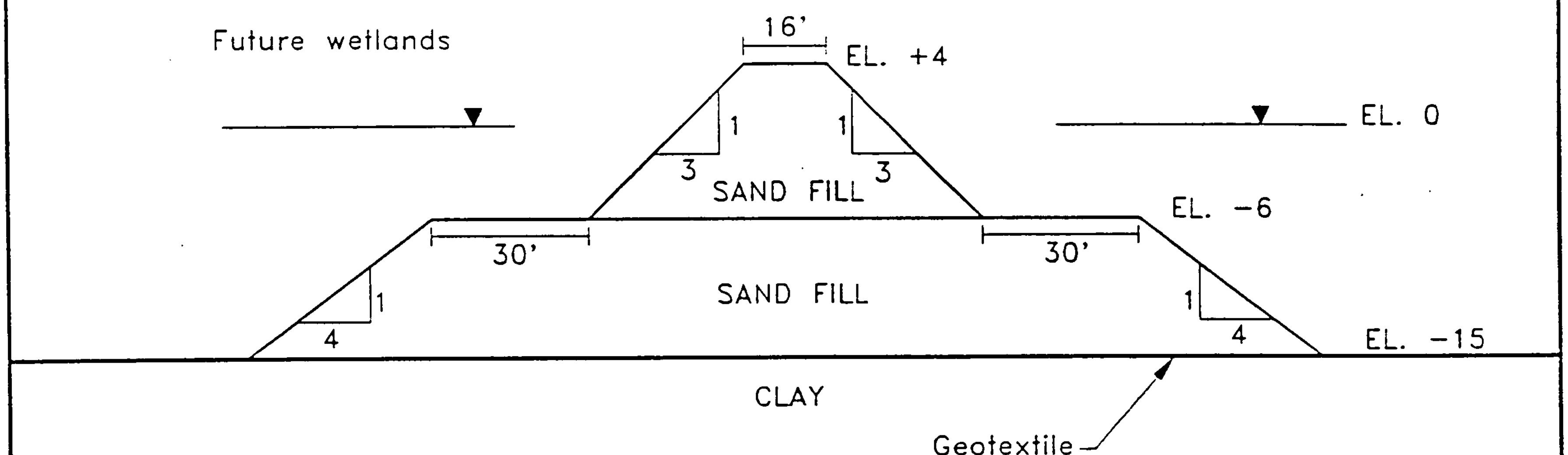
Material delivered on barges. Slag material will be unloaded and placed with a clamshell bucket.

2.5.8 Rip Rap

Rip rap bedding stone will be placed over a geotextile by clamshell bucket. Armor stone will be placed by clamshell bucket and stone grapples.

2.6 CONSTRUCTION TIME

It is estimated that various dike configurations described above can be constructed in approximately 2 - 3 months. This is from the dike embankment construction only. A total of 12 months has been allocated for the overall site construction.



PROPERTIES

SOIL	DENSITY (pcf)	COHESION (psf)	FRICTION ANGLE (Degree)
Sand	120	0	28
Clay	110	100	0 (-15 to -35)
		200	0 (-35 to -45)

VERTICAL SCALE
1 INCH = 10 FEET

HORIZONTAL SCALE
1 INCH = 30 FEET

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DIKE SECTION
ALTERNATE 1

Earth Engineering & Sciences, Inc.

Figure 3

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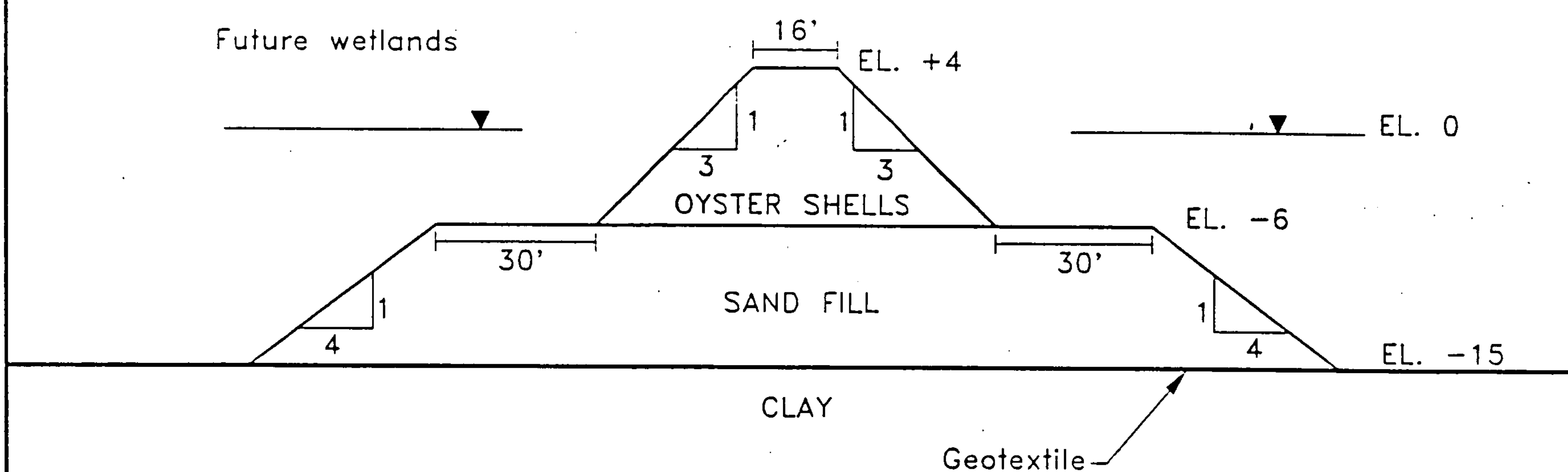

PROPERTIES

SOIL	DENSITY (pcf)	COHESION (psf)	FRICTION ANGLE (Degree)
Oyster shells	75	0	38
Sand.	120	0	28
Clay	110	100	0 (-15 to -35)
		200	0 (-35 to -45)

VERTICAL SCALE
1 INCH = 10 FEET

HORIZONTAL SCALE
1 INCH = 30 FEET

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DIKE SECTION
ALTERNATE 2

Earth Engineering & Sciences, Inc.

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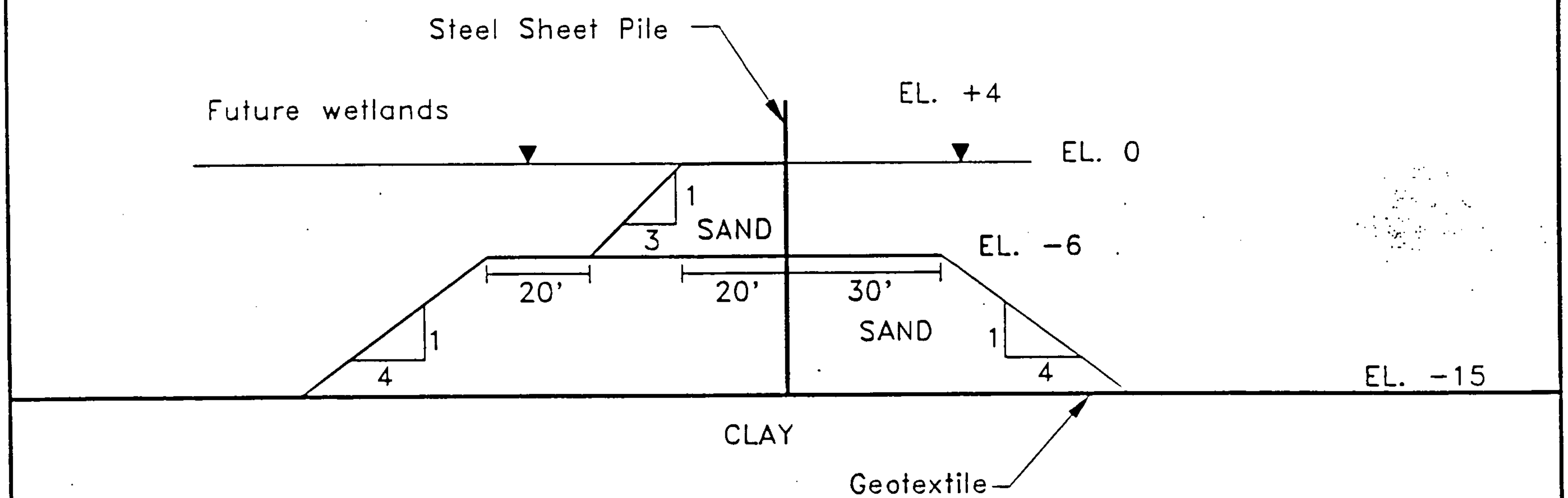
Figure 4



PROPERTIES

SOIL	DENSITY (pcf)	COHESION (psf)	FRICTION ANGLE (Degree)
Sand	120	0	28
Clay	110	100	0 (−15 to −35)
		200	0 (−35 to −45)

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VERTICAL SCALE
1 INCH = 10 FEET

HORIZONTAL SCALE
1 INCH = 30 FEET

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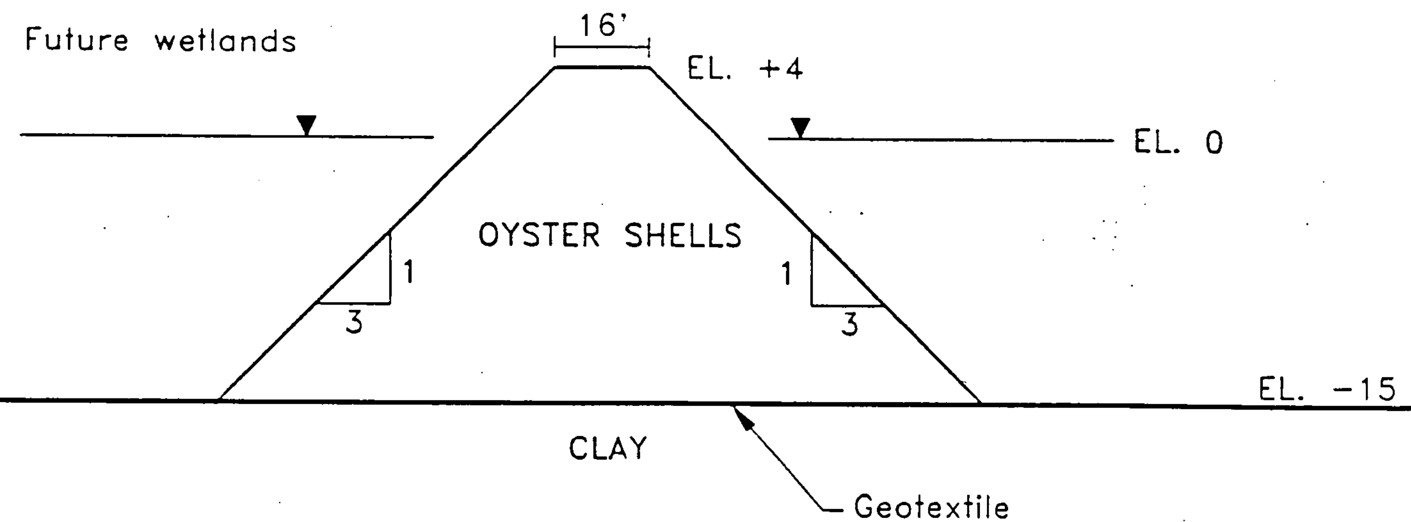
DIKE SECTION
ALTERNATE 3
Earth Engineering & Sciences, Inc.

Figure 5



PROPERTIES

SOIL	DENSITY (pcf)	COHESION (psf)	FRICTION ANGLE (Degree)
Oyster shells	75	0	38
Clay	110	100	0 (−15 to −35)
		200	0 (−35 to −45)

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DIKE SECTION
ALTERNATE 4

Earth Engineering & Sciences, Inc.

Figure 6

VERTICAL SCALE 1 INCH = 10 FEET

HORIZONTAL SCALE 1 INCH = 30 FEET

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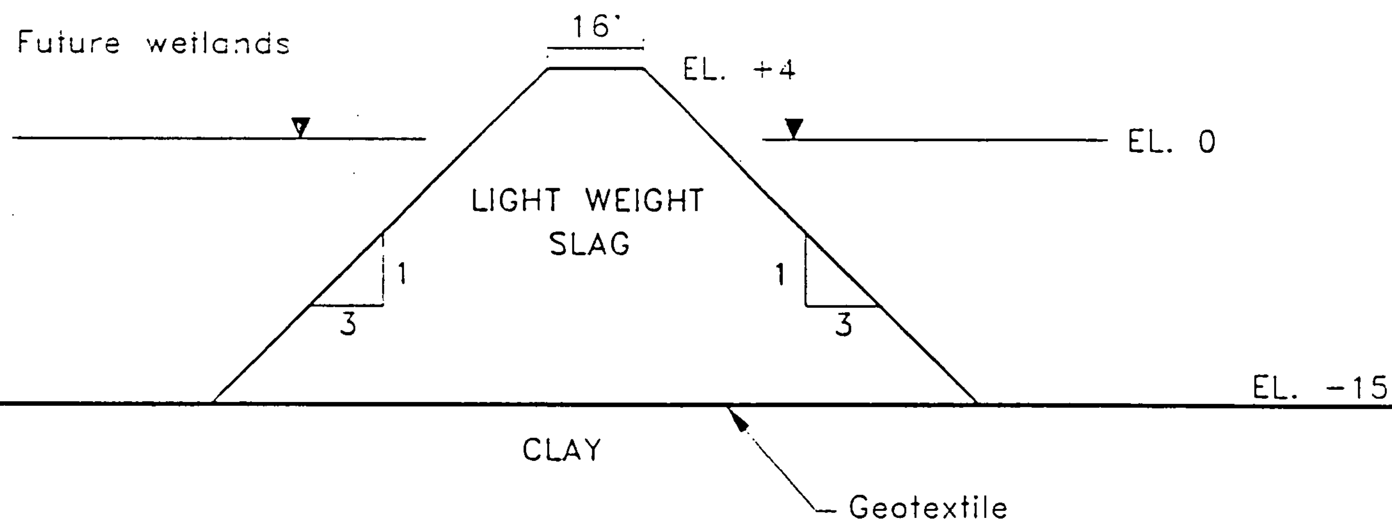

PROPERTIES

SOIL	DENSITY (pcf)	COHESION (psf)	FRICTION ANGLE (Degree)
Slag	85	–	38
Clay	110	100	0 (−15 to −35)
		200	0 (−35 to −45)

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DIKE SECTION
ALTERNATE 5
Earth Engineering & Sciences, Inc.

Figure 7

VERTICAL SCALE 1 INCH = 10 FEET
HORIZONTAL SCALE 1 INCH = 30 FEET

GAHAGAN & BRYANT ASSOCIATES, INC.

3.0 WETLAND DEVELOPMENT

The wetland evaluation and development plan prepared by Environmental Concern, Inc. (ECI) is presented in Appendix B. A brief summary of the report is given below.

3.1 IMPORTANT FACTORS IN WETLAND DEVELOPMENT

There are five principal factors in wetland development using dredged materials:

- Material Elevations
- Tidal Variation and Water Circulation
- Wetland Cell Materials
- Vegetation Types and Cultivation
- Wave Protection

3.1.1 Material Elevations

A good tidal wetland can be maintained between 0.55 feet and 1.1 feet. At the site, Mean Low Water (MLW) = 0.0 feet NGVD (National Geodetic Vertical Datum) and Mean High Water (MHW) = 1.1 feet. A high tidal wetland can be maintained from MHW to the Spring Tide Elevation, approximately 3.6 feet. A sediment maintenance program is needed to counteract settling, as there is no natural sediment source at the site. This is necessary to avoid loss of wetlands. Points 5 and 6 of Appendix B describe the plant limitations due to tidal range and duration. Above the Spring Tide Elevation, suitable terrestrial vegetation can be maintained.

3.1.2 Tidal Variation and Water Circulation

It is essential that daily tidal flooding and subsequent drainage of the wetland take place. Adequate openings are required through the containing dike for this purpose.

3.1.3 Wetland Cell Materials

The principal sources of material for the building of the wetlands will be clean silts and sands from the maintenance material dredged for the ship channels of the Outer Harbor.

3.1.4 Vegetation Types and Cultivation

Preliminary details of vegetation types and cultivation are given in Appendix B.

3.1.5 Wave Protection

The constructed wetland will require continuous protection from wave attack. This will be provided by the rip rap protected perimeter dike.

3.2 METHOD OF CONSTRUCTION

The tidal wetland will be developed on the surface of the dredged materials placed in the containment cell approximately over a 12 year period. Material must reach an elevation suitable for a tidal wetland and adequate drying and oxygenation of this material must take place before planting or seeding the wetland.

3.3 CONSTRUCTION TIME

It is estimated that seeding and planting of the wetland area can begin one year after the surface of the cell has reached the desired elevations.

4.0 UPLAND BUFFER AREA

4.1 ELEVATIONS

Existing ground elevations in the 300 feet wide river front strip for the upland dike varies in elevation from +5 to +23 MLW. The average elevation is +15. The over all dimensions of the completed Buffer Area are top elevation of +40 MLW, top width of 186 feet, and bottom width of 300 feet. Side slopes are 1 vertical on 3 horizontal.

4.2 SOURCES OF MATERIAL AND METHOD OF CONSTRUCTION

The Buffer Area will be built in annual thin lifts of three feet of hydraulically placed maintenance dredging materials. A three feet wet lift will shrink in one drying season to about 1.5 feet. The buffer cell containment dike will be raised periodically using the dried material from within the buffer cell. As an option, dried material from the buffer area can be used to reshape the existing shoreline areas.

A further option for the Buffer Area is to construct a dike with imported materials in order to provide immediate shielding of the industrial shoreline. A dike with 10 feet top width, 1 on 2.5 slopes and 15 feet in height, 5,000 feet in length will contain about 130,000 cubic yards. If this is done however, there will be less capacity for dredged material resulting in a higher unit cost of containment volume.

With a Buffer Area built of all dredged material the annual cut volume (measured in-situ in the channel) placed varies from 0.2 to 0.1 million cubic yards with the reduction in buffer cell area as the fill increases in height. The total dredged material volume placed in the buffer is estimated to be 2.6 million cubic yards after crust management.

4.3 CONSTRUCTION TIME

A Buffer Area composed entirely of dredged materials will be built in about 16 years. An area built of imported materials can be built in several months. As noted above some of the dried material from the buffer area can be use for shoreline shaping or other purposes on the site.

5.0 SITE OPERATIONAL CONSIDERATIONS

5.1 SPILLWAYS

5.1.1 Wetland Cell Area

The wetland cell will have spillways in the Southeasterly and Southwesterly corners of the cell. These spillways will have metal pipe risers and outlets with stoplogs for water level control. Gates may also be required, if specified by the permitting agencies.

5.1.2 Buffer Area

The buffer cell will have spillways at the East and West ends of the cell discharging into the wetland cell for final discharge to the Patapsco River through the wetland cell spillways. These spillways will have metal pipe risers and outlets with stoplogs for water level control.

5.2 DREDGED MATERIAL PLACEMENT PROCEDURES

As determined by the MPA Dredging Needs and Placement Options Program (October 1992), an estimated 800,000 cut cubic yards of dredged material will be delivered to the site annually. Essentially all material will be placed hydraulically either by direct pump or pumpout of scows. Some material could be unloaded mechanically but no provisions for this are planned. Also, vehicle turn arounds on top of the dikes are not considered here, but will be developed in the design stage if required. The dredging contractors will provide all unloading facilities required for their operations.

An average of 160,000 cy of fine-grained maintenance materials will be placed in the buffer cell and 640,000 cy will be placed in the wetland cell. No special operational controls are required except that relatively uniform lift thicknesses should be developed as the two cells are being filled.

5.3 CELL MATERIAL CONSOLIDATION

A preliminary estimate of wetland consolidation and desiccation has been made using the WES PCDDF model (see Figure 8). The model estimates indicate the average top of material of 3.1 ft MLW at the end of 12 years of placement. This is one foot below the top of the original dike elevation. The cell material, without additional placement will settle to about elevation +1 foot in about 3 years and will ultimately reach elevation + 0.3 feet in an additional 8 years. This demonstrates that some complexity is involved in accommodating the final dike elevations taking into account; cell elevations and settlements; material placement rates and the desired wetland elevations. The overall site development schedule and costs also has to be considered. All these factors need to be addressed in the design of the site.

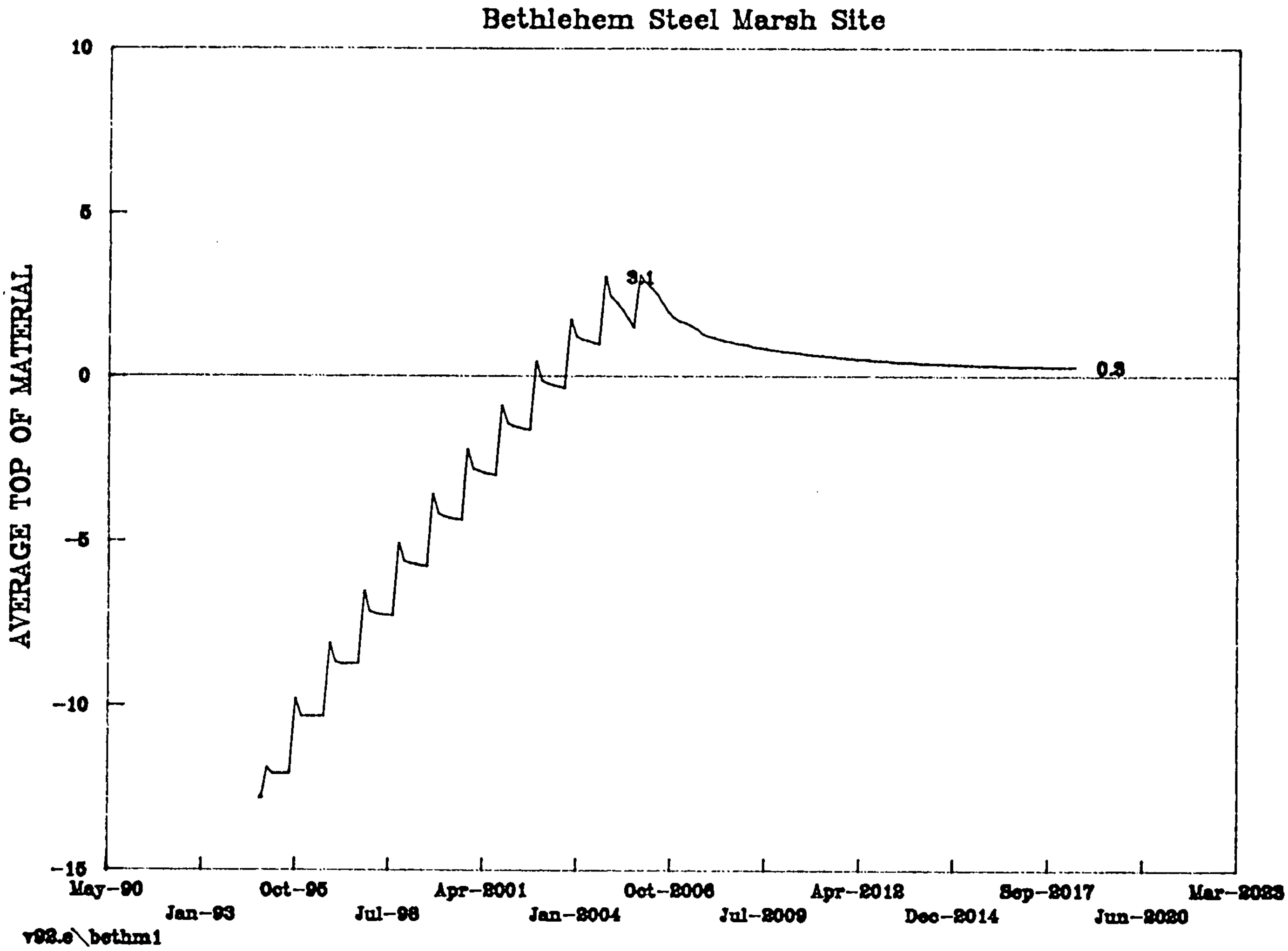

FIGURE 8

PCDDF ESTIMATE OF WETLAND CELL FILLING AND CONSOLIDATION

These results indicated that after 12 years of filling of the wetland cell at an average rate of 660,000 cubic yards per year the average elevation of material will be 3.1 feet mlw. This is one feet below the design elevation of the containment dike. Without additional placement the material will consolidate to an average elevation of about 1 feet in several years, and to 0.3 feet after a number of years. Special efforts will be required to optimize possible dike raising with cell filling and with the desired final wetland elevations.

6.0 PROJECT IMPLEMENTATION SCHEDULE

The project implementation schedule required to meet a June 1994 date to begin dredged material placement operations is very difficult to attain. A preliminary estimate of the required project milestone dates to meet the June 1994 date is presented in Table 6-1.

TABLE 6-1
PRELIMINARY PROJECT IMPLEMENTATION SCHEDULE

	Start Date	End Date
Detailed Foundation Investigations	01-Dec-92	15-Feb-93
Site Design	01-Dec-92	15-Mar-93
Site Permit Applications	01-Dec-92	01-Jan-93
Final Design Report	01-Jan-93	15-Mar-93
Contract Plans & Specifications	15-Mar-93	15-Apr-93
Advertise, Bid & Award Contract	15-Apr-93	30-May-93
Site Construction	01-Jun-93	30-May-94
Placement Operations	01-Jun-94	

7.0 PROJECT DEVELOPMENT COSTS

The estimated site first costs and operating costs are made up of the following:

- Construction Costs
  - Wetland Dike
  - Upland Buffer Area
  - Spillways
  - Design and Construction Management
- Annual Maintenance and Monitoring Costs
  - Annual Operations
  - Wetland Dike Maintenance
  - Wetland Cell Vegetation

All cost estimates are in 1992 dollars and the time value of money has not been taken into account.

7.1 CONSTRUCTION COSTS

The estimated construction costs are based on the following assumptions:

- Rip rap was calculated from elevation -6' outside the dike, across the top above elevation 0.0'
- Barge transport of rip rap and slag at $4.25/ton was used in all estimates. The rate was quoted by Arundel Corporation for transport of rip rap from the Susquehanna Quarry.
- Geotextile widths were increased by up to 20' beyond the template lines.
- $10 per square yard was used for geotextile in place
- For a contingency, 20% has been added to the total cost estimates

7.1.1 Wetland Dike Construction Cost

The preliminary estimates of construction cost for the five dike sections considered are summarized in Table 7-1.

TABLE 7-1
WETLAND DIKE CONSTRUCTION COSTS

1. Sand on Sand Berm

Geotextile (275,880 SY @ $10/SY)	$ 2,759,000
Sand (668,000 Pay CY @ $10.75/CY)	7,181,000
Geotextile Under Rip Rap (98,000 SY @ $10/SY)	980,000
#57 Stone (39,365 S.Ton @ $15/S.Ton)	591,000
Class III Rip Rap (77,100 S.Tons @ $21.20/S.Ton)	1,635,000
Total	$13,146,000

2. Oyster Shell on Sand Berm

Geotextile (275,880 SY @ $10/SY)	$ 2,759,000
Sand (568,000 Pay CY @ $11.10/CY)	6,305,000
Oyster Shells (110,110 CY @ $20/CY)	2,203,000
Geotextile Under Rip Rap (98,000 SY @ $10/SY)	980,000
#57 Stone (39,365 S.Ton @ $15/S.Ton)	591,000
Class III Rip Rap (77,100 S.Ton @ $21.20/S.Ton)	1,635,000
Total	$14,473,000

3. Sheet Pile on Sand

Geotextile (217,800 SY @ $10/SY)	$ 2,178,000
Sand (435,000 Pay CY @ $11.10/CY)	4,829,000
Sheet Pile (206,910 SF @ $20/SF)	4,138,000
Geotextile Under Rip Rap (62,920 SY @ $10/SY)	630,000
#57 Stone (20,651 S.Ton @ $15/S.Ton)	310,000
Class III Rip Rap (38,539 S.Ton @ $21.20/S.Ton)	814,000
Total	$12,899,000

TABLE 7-1
WETLAND DIKE CONSTRUCTION COSTS
(Continued)

4. Oyster Shell - Full Section

Geotextile (181,500 @ $10/SY)		$ 1,815,000
Oyster Shells (671,000 CY @ $20/CY)		13,420,000
Geotextile Under Rip Rap (98,000 SY @ $10/SY)		980,000
#57 Stone (39,365 S.Ton @ $15/S.Ton)		591,000
Class III Rip Rap (77,100 S.Ton @ $21.20/S.Ton)		1,635,000
	Total	$18,441,000

5. Lightweight Slag - Full Section

Geotextile (181,500 SY @ $10/SY)		$ 1,815,000
#57 Slag (185,900 S.Ton @ $17.50/S.Ton)		3,254,000
Pit Slag (739,200 S.Ton @ $14.20/S.Ton)		10,497,000
Geotextile Under Rip Rap (98,000 SY @ $10/SY)		980,000
#57 Stone (39,365 S.Ton @ $15/S.Ton)		591,000
Class III Rip Rap (77,100 S.Ton @ $21.20/S.Ton)		1,635,000
	Total	$18,772,000

7.1.2 Upland Buffer Area Construction Costs

Upland buffer area costs will be incurred for construction of the initial containment dike which will require approximately 360,000 cy, and for annual maintenance of the areas including periodic raising of the containing dikes using dried material from within the buffer cell. No detailed cost studies have been made except for an estimated initial cost of $1 million for development.

7.1.3 Spillways Construction Cost

There will be 6 spillways used: 2 for the upland area and 4 for the wetland area. The spillways will be standard and portable in the upland site fabricated of steel, and cost an estimated $50,000 each. There will be 4 stand pipe spillways in the wetland area which should be adequate to discharge excess water that accumulates when dikes are overtopped by large storms in the bay. Their costs are estimated to be $50,000 each.

7.1.4 Wetland Construction Costs

Materials and labor to plant a cordgrass marsh is estimated at $15,000 per acre. Seeding is established at $3,000 per acre. It is assumed for this report that one-half of the 300 acre site can be seeded and one-half planted. This results in an estimated wetland planting and seeding cost of $2.7 million. An allowance of $15,000 per year has been assumed for routine maintenance of the wetland.

7.1.5 Design and Construction Management Costs

Final design plans and specifications will take approximately three and one half months to complete.

An extensive boring and geotechnical evaluation will be required to determine the final design and exact dike alignment.

Plans & Specifications	$ 350,000
Geotechnical Evaluation	$ 400,000

Environmental Studies and Permits

No evaluations have been made of permitting requirements or environmental evaluations for this project. An allowance of $ 300,000 is included in the estimated project costs of these items.

Construction Management

During the construction period there will be a 24 hour inspection of the dike construction to insure compliance with the contract requirements. The dike will be monitored for settlement and overbuilding.

Surveys will be performed at the beginning of each shift (every 8 hours) to insure that the fill is not being placed more rapidly than the design will allow, which could cause foundation failures.

Monitoring	$ 420,000
Surveying	$ 444,000

7.2 OPERATION AND MAINTENANCE COSTS

7.2.1 Annual Operation Costs

No detailed studies of the cost of overall site administration and monitoring have been prepared. An allowance of $200,000 per year is assumed during dredging operations. A substantial reduction in such costs can be assumed at the end of site development. $50,000 per year has been assumed.

7.2.2 Wetland Dike Maintenance Cost

Dike maintenance will entail the normal maintenance of a rip rap protected fill and the periodic raising of the dike as long term settlements of the dike foundation take place. No detailed cost studies have been made and an average annual cost of $100,000 has been assumed.

7.2.3 Wetland Cell Vegetation Maintenance Cost

An allowance of $15,000 per year has been assumed for routine maintenance of the wetland.

7.2.4 Upland Buffer Area Maintenance Costs

No detailed cost studies have been made and an average annual cost of $250,000 has been assumed.

7.3 COST SUMMARY

The overall construction and maintenance costs for the various dike schemes are compared and summarized in Table 7-2.

TABLE 7-2
COST SUMMARY
(Thousands of Dollars)

	Sand On Sand	Oyster Shell & Sand	Sheet Pile & Shell	Oyster Shell	Light-weight Slag
Construction Costs					
Wetland Dike	13,146	14,473	12,899	18,441	18,772
Upland Area	1,000	1,000	1,000	1,000	1,000
Spillways	300	300	300	300	300
Wetland	2,700	2,700	2,700	2,700	2,700
Design & Construction Management	1,914	1,914	1,914	1,914	1,914
Subtotal	$19,060	$20,387	$18,813	$24,355	$24,686
Contingency @ 20%	3,840	4,113	3,787	4,845	4,914
Total Construction Cost	$22,900	$24,500	$22,600	$29,200	$29,600
Operation & Management Costs					
Annual Operations (16 yrs)	3,200	3,200	3,200	3,200	3,200
Wetland Dike (12 yrs)	1,200	1,200	1,200	1,200	1,200
Upland Area (16 yrs)	4,000	4,000	4,000	4,000	4,000
Wetland (16 yrs)	240	240	240	240	240
Subtotal	$8,640	$8,640	$8,640	$8,640	$8,640
Contingency @ 20%	1,760	1,760	1,760	1,760	1,760
Total Operation & Management Cost	$10,400	$10,400	$10,400	$10,400	$10,400
Total Cost $	**$33,300**	**$34,900**	**$33,000**	**$39,600**	**$40,000**

7.4 SITE CAPACITY COSTS

The overall site containment capacity as shown in Table 1-1 is 2,600,000 cubic yards in the upland area and 7,700,000 cubic yards in the wetlands area, totalling 10,300,000 cubic yards of contained material. This material is placed in the site over a period of 16 years. The total cost for the development, operation and maintenance of the site over the 16 year period divided by the estimated contained volume provides the unit cost per cubic yard of contained material. The unit cost for the five dike schemes is shown in Table 7-3.

TABLE 7-3
UNIT COST OF CONTAINMENT VOLUME
(Dollars Per Cubic Yard)

Dike Design	Operation & Construction	Maintenance	Total $
1. Sand on Sand	2.22	1.01	3.23
2. Oyster Shell on Sand	2.38	1.01	3.39
3. Sheet Pile & Sand	2.19	1.01	3.20
4. Oyster Shell	2.83	1.01	3.84
5. Lightweight Slag	2.87	1.01	3.88

APPENDIX A

EARTH, ENGINEERING & SCIENCES, Inc. REPORT

PRELIMINARY SUBSURFACE INVESTIGATION
BETHLEHEM SHORELINE ENHANCEMENT
BALTIMORE COUNTY

PREPARED FOR:

GAHAGAN & BRYANT ASSOCIATES, INC.
SUITE 1001
111 MARKET PLACE
BALTIMORE, MARYLAND 21202

BY:

EARTH ENGINEERING AND SCIENCES, INC.
(E2Si)
3401 CARLINS PARK DRIVE
BALTIMORE, MARYLAND 21215
PHONE: 410-466-1400
FAX : 410-466-7371

NOVEMBER 1992

Earth Engineering

3401 CARLINS PARK DRIVE BALTIMORE, MARYLAND 21215 (301) 466-1400 FAX: (301) 466-7371

November 9, 1992

Mr. Richard Thomas
Gahagan & Bryant Associates, Inc.
Suite 1001
111 Market Place
Baltimore, Maryland 21202

Re: Preliminary Subsurface Investigation
Bethlehem Steel Shoreline Enhancement
Baltimore
E2Si Project No. 92-199

Dear Mr. Thomas:

In accordance with our proposal dated September 21, 1992, and your authorization dated September 25, 1992, we have completed the preliminary subsurface investigation at the above referenced site.

Transmitted herewith are four copies of our geotechnical report.

We appreciate the opportunity of having been of service to you and look forward to being of continuing service.

Very truly yours,

EARTH ENGINEERING AND SCIENCES, INC.

Sachinder N. Gupta

Sachinder N. Gupta, P.E.
President

Enclosures

SNG/dh.414

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INTRODUCTION

This report presents the results of the subsurface investigation conducted in association with the feasibility study of building a dike for shoreline enhancement at Bethlehem Steel Yard in Baltimore County, Maryland. The investigation was conducted for Gahagan & Bryant Associates Inc., consultants to Maryland Port Administration for the feasibility study.

SITE AND PROJECT DESCRIPTION

The project site is bounded by Sparrows Point on the north, Penwood Channel on the east, Sparrows Point Channel on the west and Brewerton Channel on the south, as shown on Figure 1 and Figure 2. The area is currently under water with the depth of the water being about 15 feet over most of the site.

It is proposed to provide shoreline enhancement by creating a tidal wetland in the area. This will be accomplished by constructing a containment dike and filling behind it. The wetlands would occupy about 300 acres, and would be at about El.+2.

PURPOSE AND SCOPE

The purpose of the investigation was to evaluate the subsurface conditions at the site, on a preliminary basis, and evaluate whether or not a stable containment dike or structure can be constructed on the existing soils. It was not intended that this study be a design study, but rather, it was intended to be a feasibility/conceptual study.

The scope of our services was to drill a total of four borings, each about 60 feet deep; conduct in-situ strength tests; obtain undisturbed samples; conduct laboratory tests to evaluate the shear strength; evaluate alternate containment structures and determine whether a containment structure can be built. Determining the cost of such a structure was outside the scope of our services..

FIELD INVESTIGATION

The field investigation was conducted in October 1992. A total of four borings were drilled at the approximate locations shown on Figure 2 - Test Boring Location Plan. The borings were drilled using a truck mounted CME 75 drill rig that was placed on a steel barge. The barge was held on location with four anchors. The borings were advanced using a 4-inch casing. The casing was seated in the soil to a depth of 40 feet below the mud line. The hole was advanced using mud below that point, without advancing the casing. Standard penetration tests were conducted in each boring, at depth intervals of 2 feet to 5 feet. In-situ vane shear tests were conducted in the soft cohesive soils. Three-inch diameter undisturbed shelby tube samples were obtained in some borings. A total of 10 vane shear tests were conducted and 9 shelby tube samples were obtained. The depths of the borings varied from about 30 feet to about 80 feet below the mudline.

LABORATORY TESTING

All samples were visually classified in the laboratory by a geotechnical engineer. Selected samples were tested for their natural water content, Atterberg limits, unconfined compressive strength, consolidation characteristics. A total of 46 water contents, 10 Atterberg limits, 2 unconfined compression tests, 2 consolidation tests and 2 UV tests were performed. All tests were conducted in accordance with ASTM procedures. The results of the laboratory tests are included in the Appendix.

SUBSURFACE CONDITIONS

Geologically, the site lies to the east of the Fall Zone, in the Coastal Plain Physiographic Province. The area is underlain by recent alluvial deposits, consisting of sand, silt and clay. They are underlain by the Potomac Group. In the past, the Potomac Group was severely eroded, which resulted in deep gullies. These gullies were later filed with soft sediments, generally clays.

The subsurface conditions at the site generally consist of a mantle of very soft, gray silty clay, of highly variable thickness, underlain by dense silty sand and/or hard silty clay. The gray silty clay varies in thickness from about 10 feet at the east end of the site (near Penwood Channel) to over 90 feet at the south end (near Brewerton Channel) and over 90 feet at the west end (near Sparrows Point Channel). The silty clay has the following properties:

Density	90 pcf
Water Content	80-130%
Liquid Limit	100-120
Plastic Limit	35-40
Cohesion	100-600 psf

In general, the water content reduces with depth, and cohesion increases with depth. The clay is normally consolidated, and the water content is close to the liquid limit. The soils underlying the soft clay are either dense silty sands or hard silty clays. These hard clays have a liquid limit of about 40, plastic limit of about 20, and water contents of about 16% to 22%, as indicated by borings GBA-1 and GBA-2.

The generalized subsurface profiles are shown on Figure 3 and Figure 4.

The shear strength of the very soft clay was evaluated using several approaches. The Su/ 'c ratio of 0.3 for a PI of 70 was used to determine the in-situ strength, for a normally consolidated soil. The strength obtained by this approach was compared to the strengths obtained form in-situ vane shears, unconfined compression and unconsolidated undrained tests. This comparison is shown on Figure 5.

Based on this data, the shear strength for design purposes was assumed to be as follows:

Elevation (ft.)	Cohesion (psf)	Friction Angle (Degrees)
-15 to -35	100	0
-35 to -45	200	0
Below -45	300	0

It should be noted that these values are somewhat conservative.

EVALUATIONS AND ANALYSIS

The available data was evaluated with respect to the proposed development and is discussed below.

Assumptions

The following initial design assumptions were made:

i) The top of dike or structure will be at El. +4.

ii) The dike will be constructed from relatively clean coarse to fine sand, which will be obtained from Hart Miller Islands site, or Brewerton Channel.

iii) The sand dike will be constructed using hydraulic dredging.

iv) Overtopping of the containment structure is acceptable, since ultimately the area will be a tidal wetland.

v) The fill behind the containment structure will be at El. +2, so as to be viable as a tidal wetland.

Design Approach

It was recognized that since the soils in the upper 20 feet± area very soft (cohesion of about 100 psf), a conventional earth dike to El. +4 would probably not be stable. This was confirmed through stability analyses. Therefore, alternate solutions/ approaches were considered. These included:

1. Sand dike with stabilizing berms and geotextile (Figure 6).
2. Sand base with oyster shells dike on top, and geotextile at bottom (Figure 7).
3. Sand base with geotextile at bottom and sheet pile to El. +4 (Figure 8).
4. Dike constructed of all oyster shells with geotextile (Figure 9).
5. Dike constructed of all light weight slag with geotextile (Figure 10).

The concept of each of these schemes was to reduce the weight, and hence the driving forces. It was established that light weight materials, such as oyster shells and light weight slag were available locally and in sufficient quantities to construct the dike. A combination of sand base with oyster shell (or slag) dike was also considered to reduce the volume of shells,and therefore reduce cost.

Since the soils are very soft, it is believed that some displacement of the upper 2 feet ± could occur. To minimize this, and to increase the overall stability, a high strength geotextile was included in each of the above alternates.

Consideration was given to other concepts that include increasing the shear strength of the soil by wicks, sand columns or stone columns. All of these were considered to be rather expensive because of the thickness of the very soft soils, and were not evaluated any further.

The following design parameters were used in the slope stability analysis:

Material	Density (pcf)	Cohesion (psf)	Friction Angle (Degrees)
Sand	120	0	28
Oyster shells	75	0	38
Light weight slag	85	0	38
Foundation clay	110	100	0 (El.-15 to El.-35)
		200	0 (El.-35 to El.-45)
		300	0 (Below El.-45)

Analysis

Slope stability analysis were conducted to evaluate deep seated failures using STABL V computer program, for each of the alternates. The results are summarized below.

Alternate	F.S.
1. All sand, with stabilizing berms and geotextile	<1
2. Sand base (to El. -6) with oyster shells dike on top, geotextile on bottom	1.3
3. Sand base (to El. -6) with geotextile at bottom, and sheet pile to El. +4	1.05

4. All oyster shells with geotextile 1.7

5. All light weight slag with geotextile 1.25

It is apparent that an all sand dike with stabilizing berms has an unacceptably low factor of safety. The factor of safety could be increased by lengthening the stabilizing berms. However, this detail is beyond the scope of this conceptual study and can be further evaluated in the final design phase.

Sand dike with steel sheet pile also has a low factor of safety. With some refinements, the factor of safety can be increased.

Sand base with oyster shells dike on top, dike made entirely of oyster shells, and dike made entirely of light weight slag each has a factor of safety in excess of 1.2, and is therefore considered viable.

It should be noted that the sloped surface and the top of the dike in each alternate will need to be protected from wave action, using rip-rap. The lines shown on the sketches are for outside of rip-rap i.e. rip-rap is within the lines shown.

Analysis of consolidation tests indicate that for a slag dike, a settlement of about 2 feet should be expected under the crest of the dike. For oyster shell dike, the settlements would be somewhat smaller.

CONCLUSIONS

The preliminary investigation indicates that a containment structure can be built at the site as shown on Figures 7, 9 and 10, inspite of the very soft soils extending to deep depths, in water up to 15 feet deep. Oyster shells, light weight slag, or a sand base with oyster shell or slag upper dike can be used. The effect of slag on the life of the geotextile has not been considered at this stage, but should be evaluated in the final design.

Extensive geotechnical investigation will need to be conducted and the conceptual design modified/fine tuned to obtain an optimum and economic design. The construction will need to be monitored very closely by the geotechnical designers to minimize/prevent mud waves and other problems during construction.

It is our opinion, based on the rather limited data, that a light weight material should be used to construct the dike. This, along with the geotextile, will minimize the displacement of very soft clays at the surface, and will minimize "mud waves".

Earth Engineering & Sciences, Inc.

APPENDIX

Earth Engineering & Sciences, Inc.

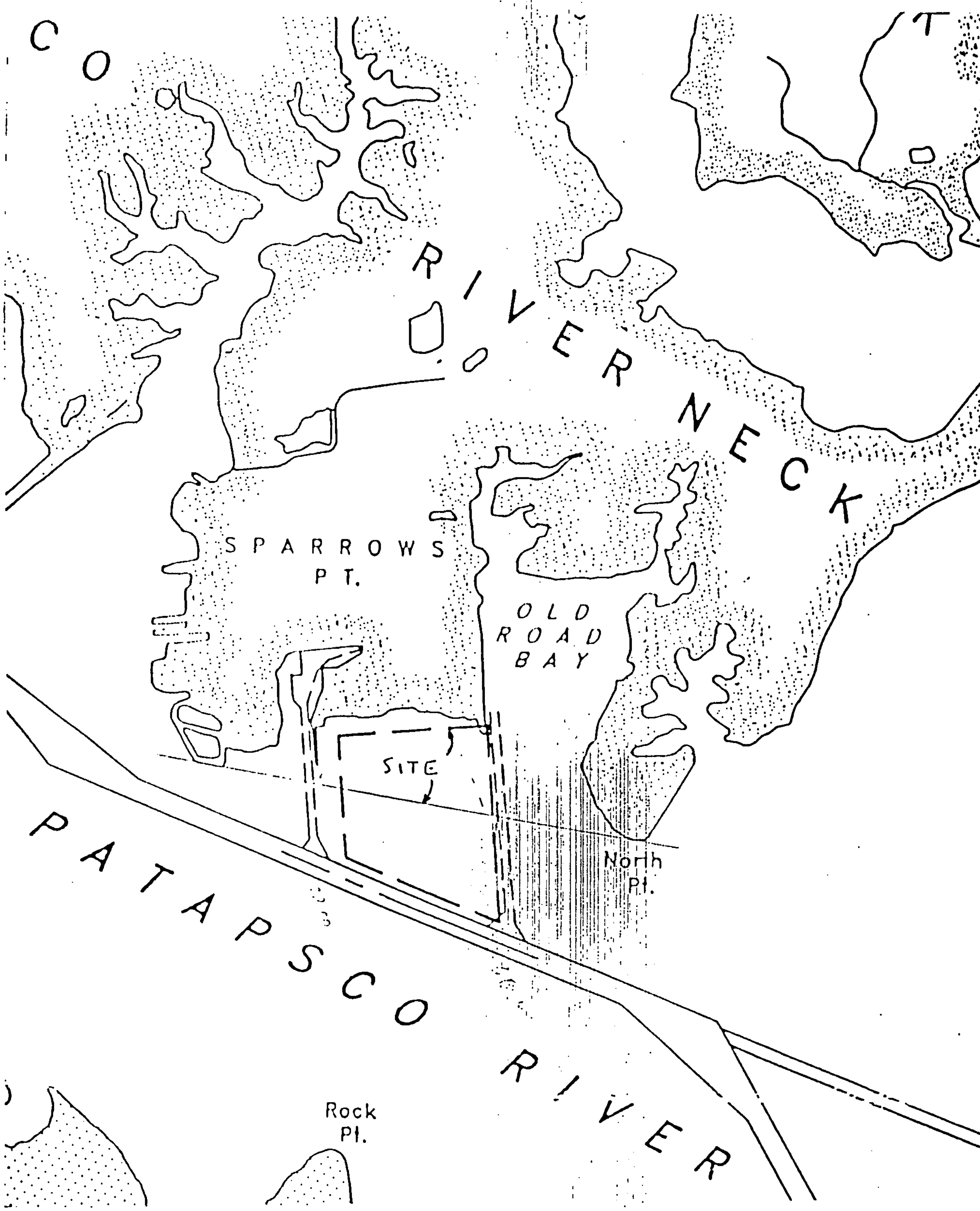
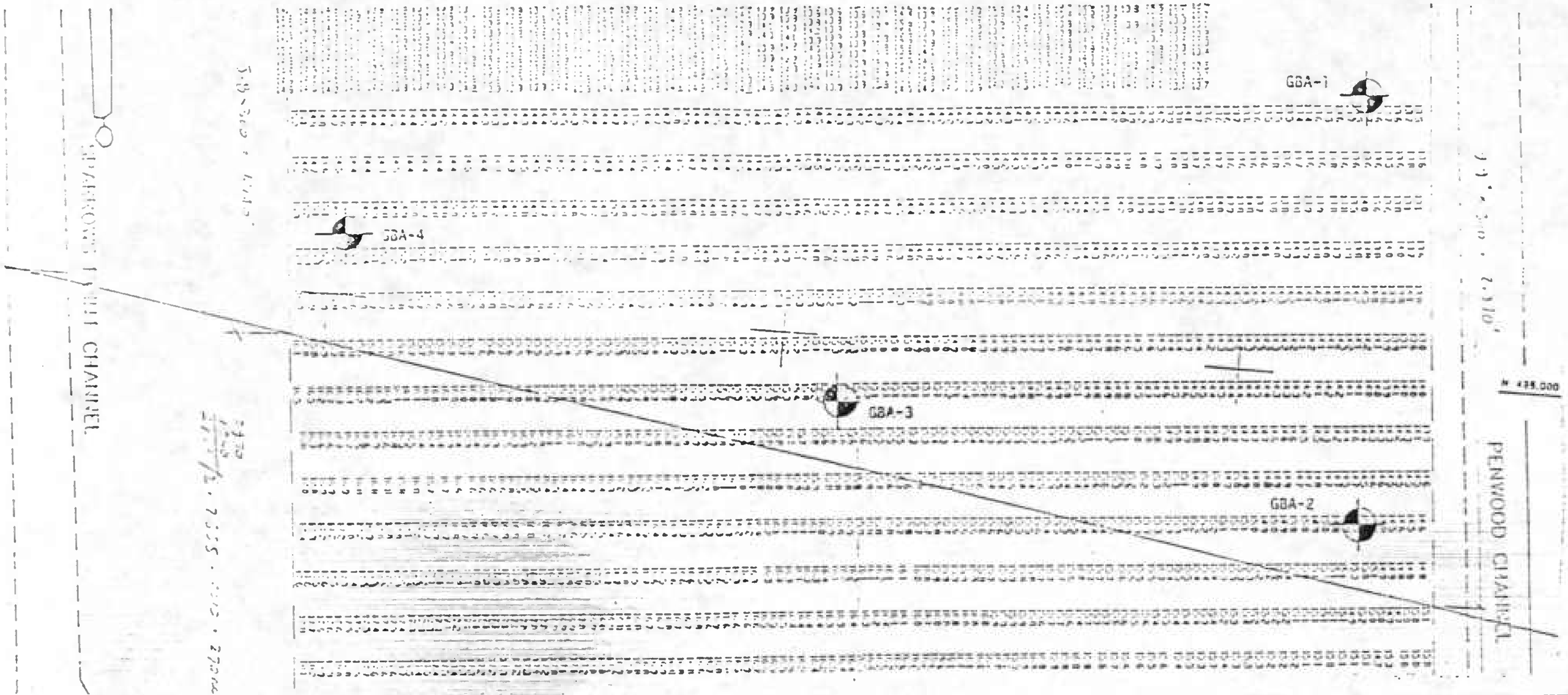


FIGURE 1: SITE VICINITY MAP

BETHLEHEM SHORELINE ENHANCEMENT

E2Si PROJECT NO. 92-199



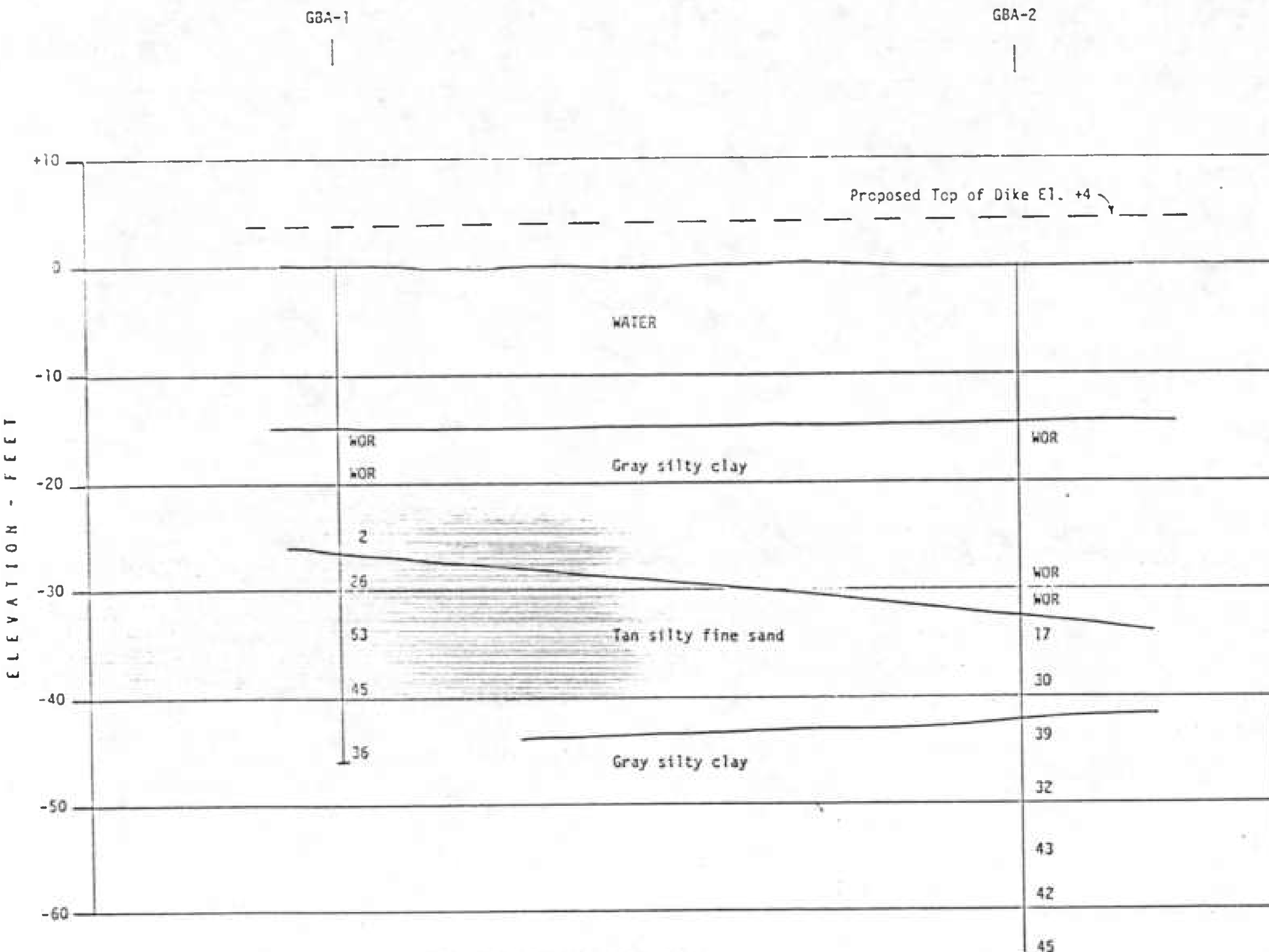
BETHLEHEM STEEL SHORELINE ENHANCEMENT

BALTIMORE COUNTY

Earth Engineering & Sciences, Inc.

TEST BORING LOCATION PLAN

FIGURE: 2	DRAWN BY:	CHECKED BY:
DATE: Oct. 92	JOB NO.: 92-199	SCALE:



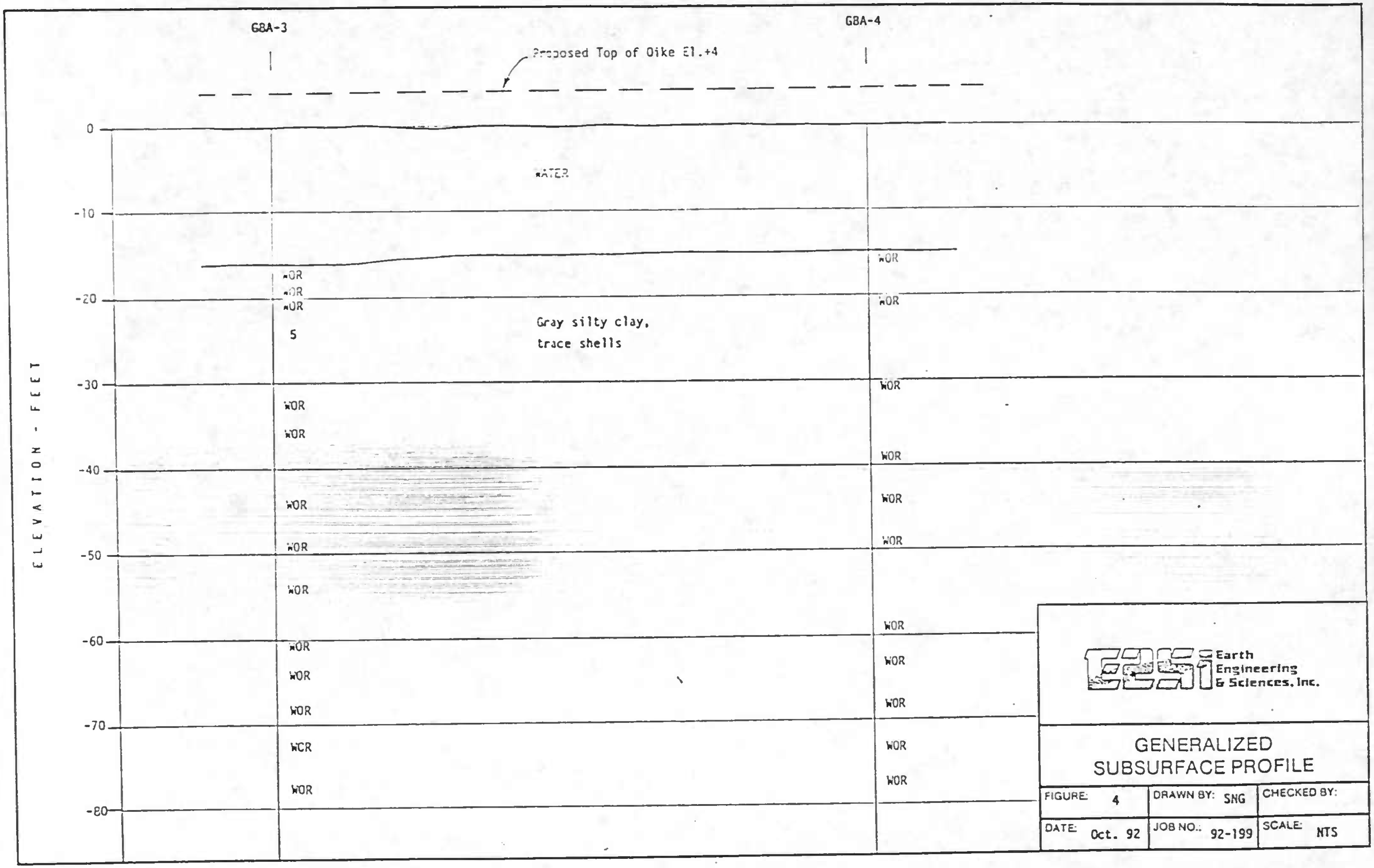
BETHLEHEM SHORELINE ENHANCEMENT

BALTIMORE COUNTY

Earth Engineering & Sciences, Inc.

GENERALIZED SUBSURFACE PROFILE

FIGURE: 3	DRAWN BY: SNG	CHECKED BY:
DATE: Oct. 92	JOB NO.: 92-199	SCALE: NTS

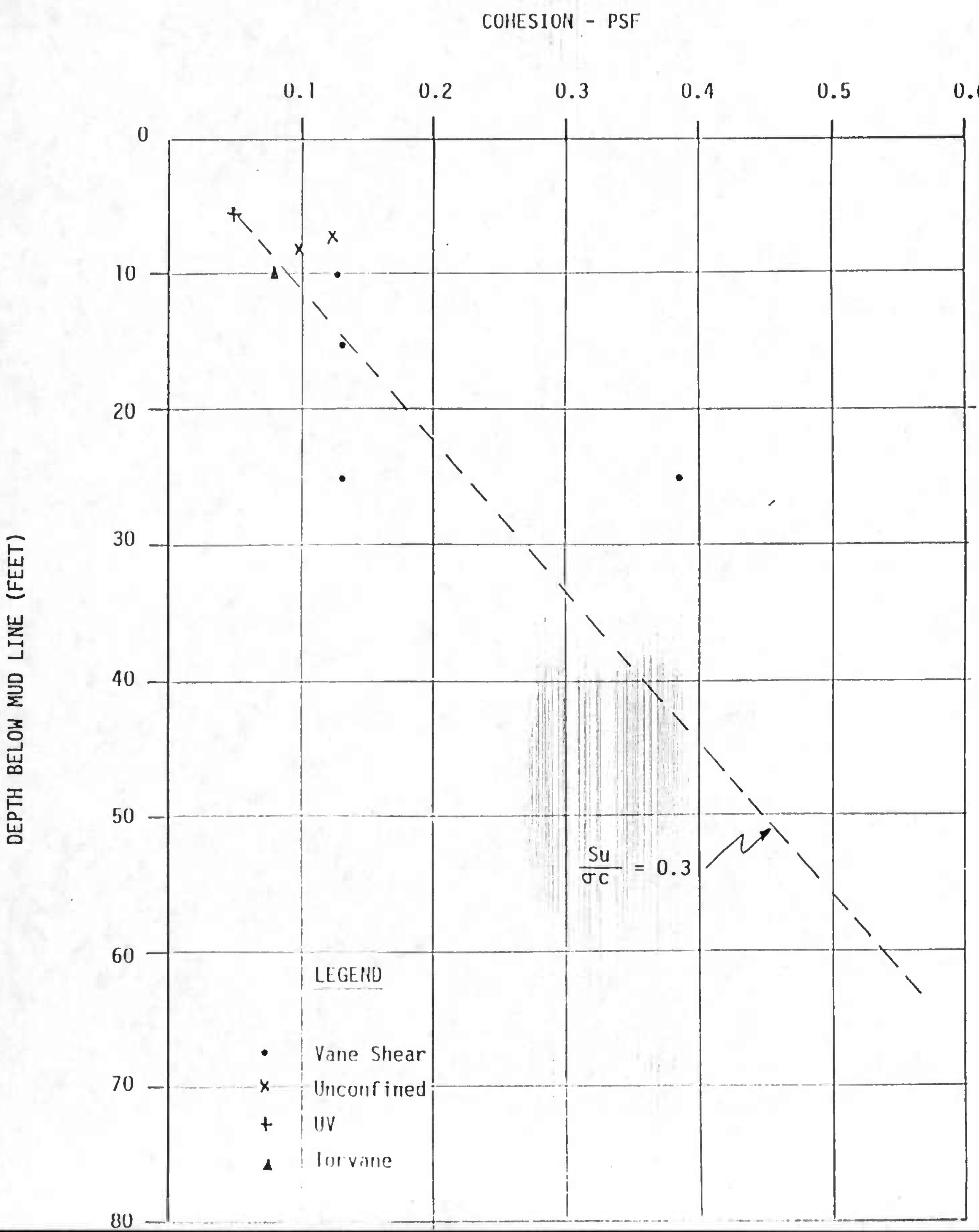


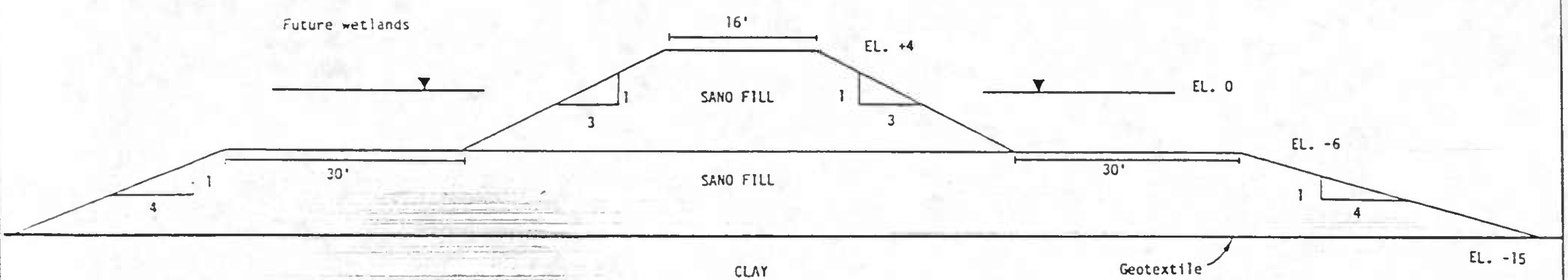
GENERALIZED SUBSURFACE PROFILE

FIGURE: 4	DRAWN BY: SNG	CHECKED BY:
DATE: Oct. 92	JOB NO.: 92-199	SCALE: NTS

Earth
Engineering
& Sciences, Inc.

FIGURE 5: SUMMARY OF SHEAR STRENGTH DATA





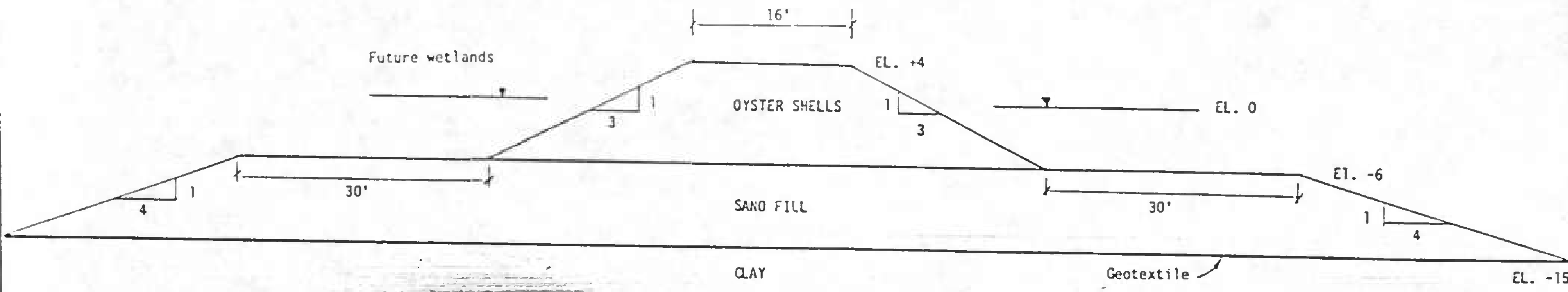
PROPERTIES

SOIL	DENSITY (pcf)	COHESION (psf)	FRICTION ANGLE (Degree)
Sand	120	0	28
Clay	110	100	0 (-15 to -35)
		200	0 (-35 to -45)

Earth Engineering & Sciences, Inc.

DIKE SECTION
ALTERNATE 1

FIGURE: 6	DRAWN BY: SNG	CHECKED BY:
DATE: Oct. 92	JOB NO.: 92-199	SCALE: NTS



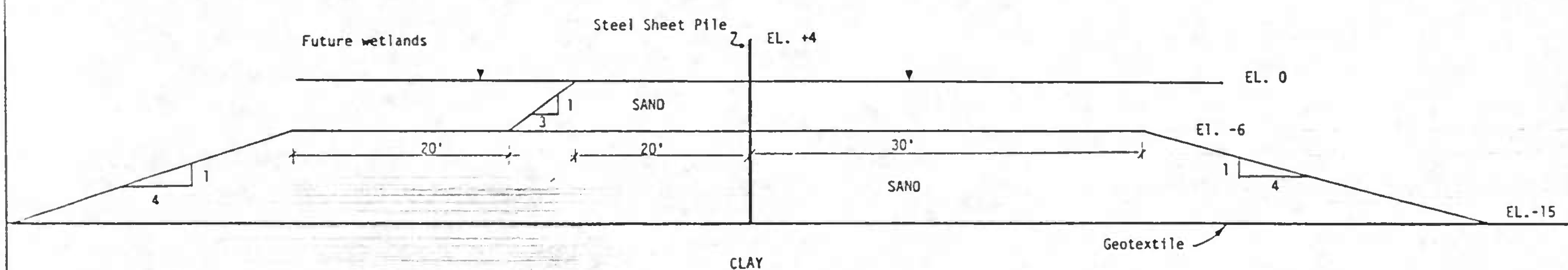
PROPERTIES

SOIL	DENSITY (pcf)	COHESION (psf)	FRICTION ANGLE (Degrees)
Oyster shells	75	0	38
Sand	120	0	28
Clay	110	100	0 (-15 to -35)
		200	0 (-35 to -45)

EESI Earth Engineering & Sciences, Inc.

DIKE SECTION
ALTERNATE 2

FIGURE: 7	DRAWN BY: SNG	CHECKED BY:
DATE: Oct. 92	JOB NO.: 92-199	SCALE: NTS



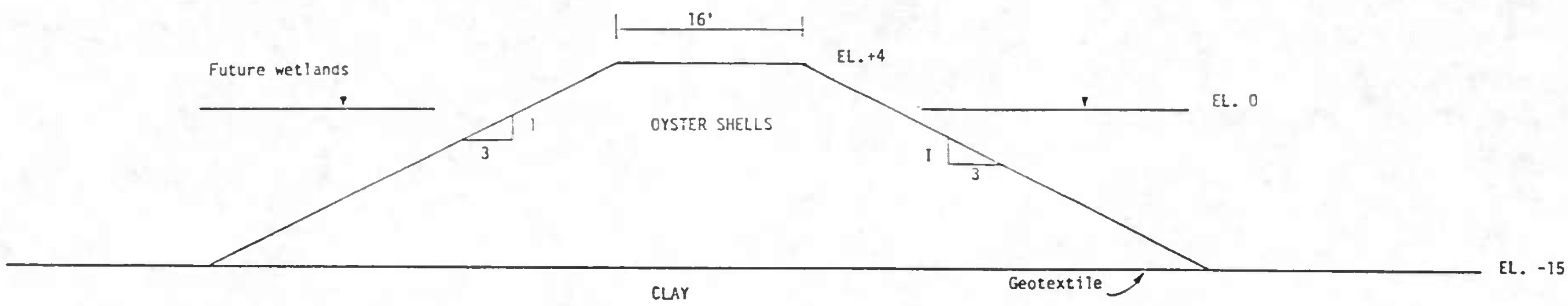
PROPERTIES

SOIL	DENSITY (pcf)	COHESION (psf)	FRICTION ANGLE (Degrees)
Sand	120	0	28
Clay	110	100	0 (-15 to -35)
		200	0 (-35 to -45)

Earth Engineering & Sciences, Inc.

DIKE SECTION
ALTERNATE 3

FIGURE: 8	DRAWN BY: SNG	CHECKED BY:
DATE: Oct. 92	JOB NO.: 92-199	SCALE: NTS



PROPERTIES

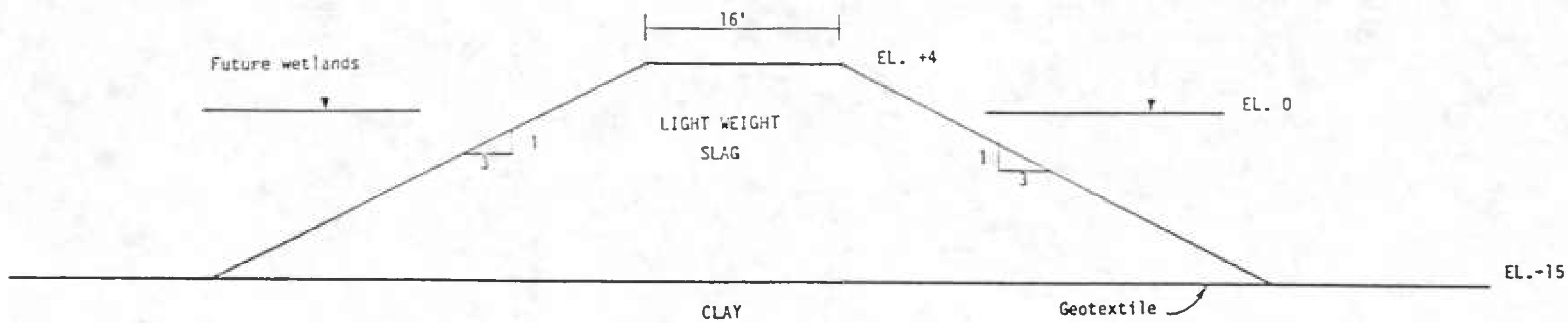
SOIL	DENSITY (pcf)	COHESION (psf)	FRICTION ANGLE (Degrees)
Oyster shells	75	0	38
Clay	110	100	0 (-15 to -35)
		200	0 (-35 to -45)

Earth Engineering & Sciences, Inc.

DIKE SECTION

ALTERNATE 4

FIGURE: 9	DRAWN BY: SNG	CHECKED BY:
DATE: Oct. 92	JOB NO.: 92-199	SCALE: NTS



PROPERTIES

SOIL	DENSITY (pcf)	COHESION (psf)	FRICTION ANGLE (Degrees)
Slag	85	-	38
Clay	110	100	0 (-15 to -35)
		200	0 (-35 to -45)

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DIKE SECTION
ALTERNATE 5

FIGURE: 10	DRAWN BY: SNG	CHECKED BY:
DATE: Oct. 92	JOB NO.: 92-199	SCALE: NTS

Earth Engineering & Sciences, Inc.

BORING LOG

PROJECT Bethlehem Shoreline Enhancement
Baltimore County

BORING No. GBA-1 (1 of 2)

PROJECT No. 92-199

LOCATION OF BORING

ELEV. 0 DATE: START 10-21-92 FINISH 10-21-92 INSPECTOR

HAMMER 140 lbs. HAMMER DROP 30 in. SPOON OD 2 in. FOREMAN D. Krahl

BORING METHOD D.C. ROCK CORE DIA MISC.

ELEV.	SOIL DESCRIPTION	DEPTH	BLOWS 6"	No.	TYPE	REC	REMARKS
	WATER	5					
		10					
		15					
	Gray silty clay, trace shells		WOR	1	DS		
		20	WOR	2	DS		
		25	WOR/6-1-1	3	DS		
	Tan, very fine sandy silt	30	8-8-18	4	DS		
	Tan, light gray silty fine sand	35	10-25-28	5	DS		
		40	12-17-28	6	DS		

LEGEND
DS DRIVEN SPOON
ST SHELBY TUBE
PS PISTON SAMPLE
RC ROCK CORE

GROUND WATER
AT COMPLETION ______ CAVED ______
AT ______ HRS. ______ CAVED ______

HSA HOLLOW STEM AUGER
DC DRIVEN CASING
MD MUD DRILLING

Earth Engineering & Sciences, Inc.

BORING LOG

PROJECT Bethlehem Shoreline Enhancement
Baltimore County

BORING No. GBA-1 (2 of 2)
PROJECT No. 92-199

LOCATION OF BORING

ELEV. 0 DATE: START 10-21-92 FINISH 10-21-92 INSPECTOR

HAMMER 140 lbs. HAMMER DROP 30 in. SPOON OD 2 in. FOREMAN D. Krahl

BORING METHOD DC ROCK CORE DIA MISC.

ELEV.	SOIL DESCRIPTION	DEPTH	BLOWS 6"	No.	TYPE	REC	REMARKS
	Tan, gray sandy silt	45	9-16-20	7	DS		
	Bottom of Boring at 45.5 feet.						
		50					

LEGEND
DS DRIVEN SPOON
ST SHELBY TUBE
PS PISTON SAMPLE
RC ROCK CORE

GROUND WATER
AT COMPLETION ______ CAVED ______
AT ______ HRS. ______ CAVED ______

HSA HOLLOW STEM AUGER
DC DRIVEN CASING
MD MUD DRILLING

Earth Engineering & Sciences, Inc.

BORING LOG

PROJECT Bethlehem Shoreline Enhancement
Baltimore County

BORING No. GBA-2 (1 of 2)

PROJECT No. 92-199

LOCATION OF BORING

ELEV. 0 DATE: START 10-20-92 FINISH 10-20-92 INSPECTOR

HAMMER 140 lbs. HAMMER DROP 30 in. SPOON OD 2 in. FOREMAN D. Krahl

BORING METHOD DC ROCK CORE DIA MISC.

ELEV.	SOIL DESCRIPTION	DEPTH	BLOWS 6"	No.	TYPE	REC	REMARKS
	WATER						
		5					
		10					
	Gray silty clay, trace shells	15	WOR/18	1	DS		
		20	PUSH	U-1	PT		
			PUSH	U-2	PT		
		25	PUSH	U-3	PT		
			WOR/18	2	DS		
		30	WOR/12 WOR/6	3	DS		
	Tan, orange, silty fine sand		5-7-10	4	DS		
		35					
		40	8-12-18	5	DS		

LEGEND
DS DRIVEN SPOON
ST SHELBY TUBE
PS PISTON SAMPLE
RC ROCK CORE

GROUND WATER
AT COMPLETION ______ CAVED ______
AT ______ HRS. ______ CAVED ______

HSA HOLLOW STEM AUGER
DC DRIVEN CASING
MD MUD DRILLING

Earth Engineering & Sciences, Inc.

BORING LOG

PROJECT Bethlehem Shoreline Enhancement
Baltimore County

BORING No. GBA-2 (2 of 2)
PROJECT No. 92-199

LOCATION OF BORING

ELEV. 0 DATE: START 10-20-92 FINISH 10-20-92 INSPECTOR

HAMMER 140 lbs. HAMMER DROP 30 in. SPOON OD 2 in. FOREMAN D. Krahl

BORING METHOD DC ROCK CORE DIA MISC.

ELEV.	SOIL DESCRIPTION	DEPTH	BLOWS 6"	No.	TYPE	REC	REMARKS
	Tan silty fine sand						
	Gray silty clay	45	10-15-24	6	DS		
	Light gray silty clay	50	6-12-20	7	DS		
	Dark gray silty clay	55	12-17-26	8	DS		
	Gray silt, little sand	60	12-19-23	9	DS		
	Light gray silty clay	65	15-21-24	10	DS		
	Bottom of Boring at 64.5 feet.	70					

LEGEND
DS DRIVEN SPOON
ST SHELBY TUBE
PS PISTON SAMPLE
RC ROCK CORE

GROUND WATER
AT COMPLETION ______ CAVED ______
AT ______ HRS. ______ CAVED ______

HSA HOLLOW STEM AUGER
DC DRIVEN CASING
MD MUD DRILLING

Earth Engineering & Sciences, Inc.

BORING LOG

PROJECT: Bethlehem Shoreline Enhancement

Baltimore County

BORING No. GBA-3 (1 of 3)

PROJECT No. 92-199

LOCATION OF BORING

ELEV. 0 DATE: START 10-16-92 FINISH 10-16-92 INSPECTOR

HAMMER 140 lbs. HAMMER DROP 30 in. SPOON OD 2 in. FOREMAN D. Krahl

BORING METHOD DC ROCK CORE DIA MISC.

ELEV.	SOIL DESCRIPTION	DEPTH	BLOWS 6"	No.	TYPE	REC	REMARKS
	WATER						
		5					
		10					
		15					
	Gray silty clay, trace shells		WOR/8	1	DS		
			WOR/18	2	DS		
		20					
			VS	-	-		c = 50 psf
			3-2-3	3	DS		
		25	PUSH	U-1	PT		
			VS	-	-		c = 130 psf
			PUSH	U-2	PT		
		30	VS	-	-		c = 65 psf
		35	WOR/18	4	DS		
			WOR/18	5	DS		
		40	VS	-	-		c = 390 psf

LEGEND
DS DRIVEN SPOON
ST SHELBY TUBE
PS PISTON SAMPLE
RC ROCK CORE

GROUND WATER
AT COMPLETION ______ CAVED ______
AT ______ HRS. ______ CAVED ______

HSA HOLLOW STEM AUGER
DC DRIVEN CASING
MD MUD DRILLING

Earth Engineering & Sciences, Inc.

BORING LOG

PROJECT Bethlehem Shoreline Enhancement
Baltimore County

BORING No. GBA-3 (2 of 3)

PROJECT No. 92-199

LOCATION OF BORING

ELEV. 0 DATE: START 10-16-92 FINISH 10-16-92 INSPECTOR

HAMMER 140 lbs. HAMMER DROP 30 in. SPOON OD 2 in. FOREMAN D. Krahl

BORING METHOD DC ROCK CORE DIA MISC.

ELEV.	SOIL DESCRIPTION	DEPTH	BLOWS 6"	No.	TYPE	REC	REMARKS
	Gray silty clay, trace shells	45	WOR/18	6	DS		
		50	WOR/18	7	DS		
		55	WOR/18	8	DS		
			VS	-	-		c = 650 psf
		60	WOR/18	9	DS		
		65	WOR/18	10	DS		
		70	WOR/18	11	DS		
		75	WOR/18	12	DS		
		80	WOR/18	13	DS		

LEGEND
DS DRIVEN SPOON
ST SHELBY TUBE
PS PISTON SAMPLE
RC ROCK CORE

GROUND WATER
AT COMPLETION ______ CAVED ______
AT ______ HRS. ______ CAVED ______

HSA HOLLOW STEM AUGER
DC DRIVEN CASING
MD MUD DRILLING

Earth Engineering & Sciences, Inc.

BORING LOG

PROJECT Bethleheme Shoreline Enhancement
Baltimore County

BORING No. GBA-3 (3 of 3)

PROJECT No. 92-199

LOCATION OF BORING

ELEV. 0 DATE: START 10-16-92 FINISH 10-16-92 INSPECTOR

HAMMER 140 lbs. HAMMER DROP 30 in. SPOON OD 2 in. FOREMAN D. Krahl

BORING METHOD DC ROCK CORE DIA MISC.

ELEV.	SOIL DESCRIPTION	DEPTH	BLOWS 6"	No.	TYPE	REC	REMARKS
	Gray silty clay, trace shells						
		85	WOR/18	14	DS		
		90	WOR/12 WOH/6	15	DS		
		95	WOH/18	16	DS		
	Bottom of Boring at 95.0 feet.						

LEGEND
DS DRIVEN SPOON
ST SHELBY TUBE
PS PISTON SAMPLE
RC ROCK CORE

GROUND WATER
AT COMPLETION CAVED
AT HRS. CAVED

HSA HOLLOW STEM AUGER
DC DRIVEN CASING
MD MUD DRILLING

Earth Engineering & Sciences, Inc.

BORING LOG

PROJECT Bethlehem Shoreline Enhancement
Baltimore County

BORING No. GBA-4 (1 of 3)
PROJECT No. 92-199

LOCATION OF BORING

ELEV. 0 DATE: START 10-15-92 FINISH 10-15-92 INSPECTOR

HAMMER 140 lbs. HAMMER DROP 30 in. SPOON OD 2 in. FOREMAN D. Krahl

BORING METHOD DC ROCK CORE DIA MISC.

ELEV.	SOIL DESCRIPTION	DEPTH	BLOWS 6"	No.	TYPE	REC	REMARKS
	WATER						
		5					
		10					
		15					
	Gray silty clay, trace shells		WOR/18	1	DS		
			VS	-	-		c = 0
		20					
			WOR/18	2	DS		
		25					
			PUSH	U-1	PT		
			VS	-	-		c = 130 psf
		30	WOR/18	3	DS		
			PUSH	U-2	PT		
		35					
		40	WOR/18	4	DS		

LEGEND
DS DRIVEN SPOON
ST SHELBY TUBE
PS PISTON SAMPLE
RC ROCK CORE

GROUND WATER
AT COMPLETION ______ CAVED ______
AT ______ HRS. ______ CAVED ______

HSA HOLLOW STEM AUGER
DC DRIVEN CASING
MD MUD DRILLING

Earth Engineering & Sciences, Inc.

BORING LOG

PROJECT Bethlehem Shoreline Enhancement
Baltimore County

BORING No. GBA-4 (2 of 3)

PROJECT No. 92-199

LOCATION OF BORING

ELEV. 0 DATE: START 10-15-92 FINISH 10-15-92 INSPECTOR

HAMMER 140 lbs. HAMMER DROP 30 in. SPOON OD 2 in. FOREMAN D. Krahl

BORING METHOD DC ROCK CORE DIA MISC.

ELEV.	SOIL DESCRIPTION	DEPTH	BLOWS 6"	No.	TYPE	REC	REMARKS
	Gray silty clay, trace shells		VS	-	-		c = 130 psf
		45	WOR/18	5	DS		
			VS	-	-		c = 1170 psf
		50	WOR/6 WOH/12	6	DS		
		55	PUSH	U-3	PT		
		60	WOR/18	7	DS		
		65	WOR/18	8	DS		
		70	WOR/18	9	DS		
		75	WOR/18	10	DS		
		80	WOR/18	11	DS		

LEGEND
DS DRIVEN SPOON
ST SHELBY TUBE
PS PISTON SAMPLE
RC ROCK CORE

GROUND WATER
AT COMPLETION ______ CAVED ______
AT ______ HRS. ______ CAVED ______

HSA HOLLOW STEM AUGER
DC DRIVEN CASING
MD MUD DRILLING

Earth Engineering & Sciences, Inc.

BORING LOG

PROJECT Bethlehem Shoreline Enhancement
Baltimore County

BORING No. GBA-4 (3 of 3)

PROJECT No. 92-199

LOCATION OF BORING

ELEV. 0 DATE: START 10-15-92 FINISH 10-15-92 INSPECTOR

HAMMER 140 lbs. HAMMER DROP 30 in. SPOON OD 2 in. FOREMAN D. Krahl

BORING METHOD DC ROCK CORE DIA MISC.

ELEV.	SOIL DESCRIPTION	DEPTH	BLOWS 6"	No.	TYPE	REC	REMARKS
	Gray silty clay, trace shells						
			WOR/18	12	DS		
		85	VS	-	-		
		90	WOH/18	13	DS		
		95	WOH/18	14	DS		
	Bottom of Boring at 95.0 feet.						

LEGEND
DS DRIVEN SPOON
ST SHELBY TUBE
PS PISTON SAMPLE
RC ROCK CORE

GROUND WATER
AT COMPLETION ______ CAVED ______
AT ______ HRS. ______ CAVED ______

HSA HOLLOW STEM AUGER
DC DRIVEN CASING
MD MUD DRILLING

Earth Engineering & Sciences, Inc.

SUMMARY OF LABORATORY TEST DATA

Boring	Sample	Water Content	Liquid Limit	Plasticity Index
GBA-1	S-1	147.9		
	S-2	122.8		
	S-3	93.3		
	S-4	22.2	25	9
	S-5	25.6		
	S-6	22.8		
	S-7	17.8		
GBA-2	S-2	93.9		
	S-3	86.5	109	77
	S-4	20.8		
	S-5	21.0	39	15
	S-6	20.2		
	S-7	24.9		
	S-8	19.0		
	S-9	16.7	39	20
	S-10	15.8		
GBA-3	S-1	177.7		
	S-2	47.2		
	S-3	34.1	48	20
	S-4	122.1		
	S-5	119.6		
	S-6	115.5	119	75
	S-7	109.6		

Earth Engineering & Sciences, Inc.

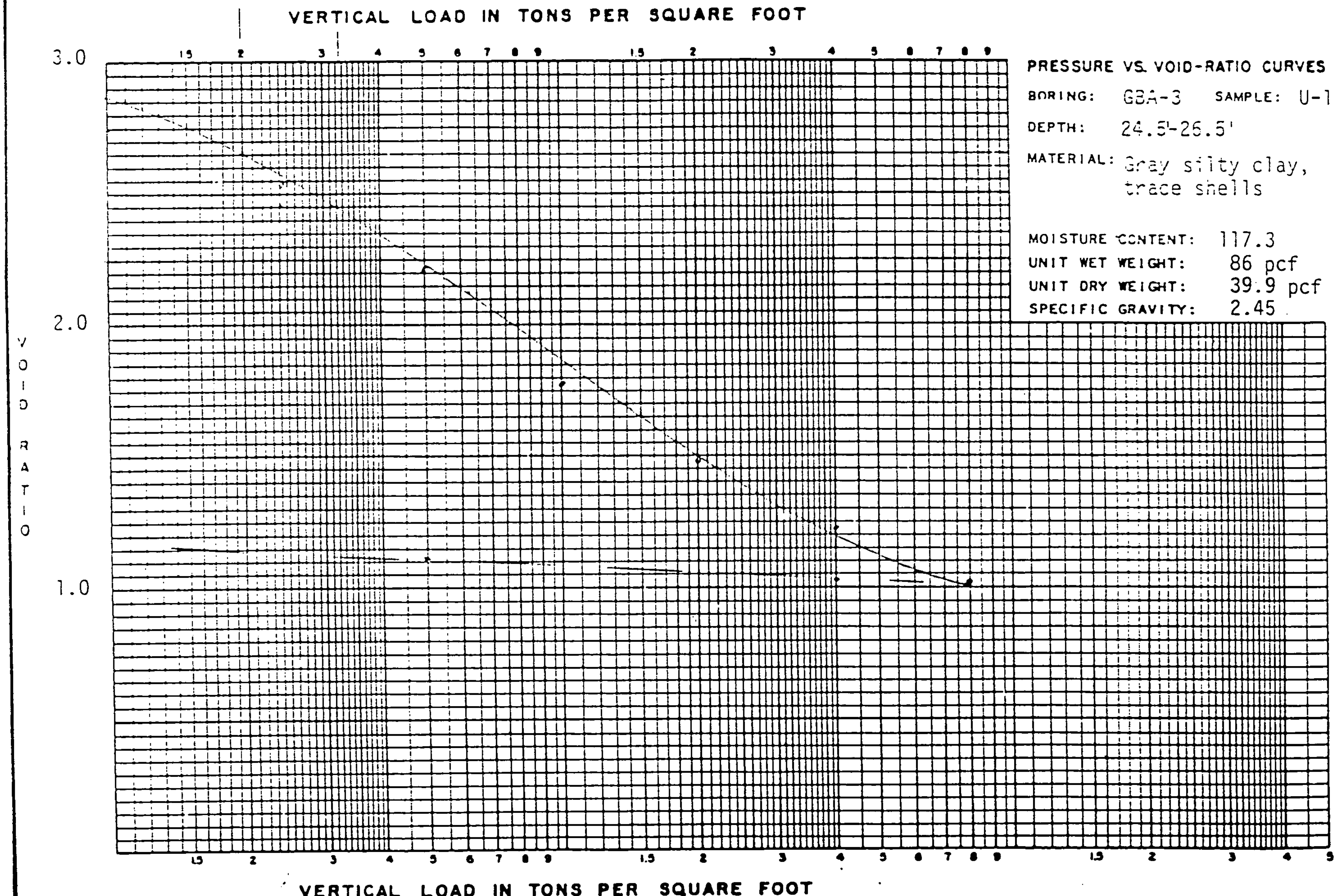
Summary of Laboratory Test Data (Cont'd)

Boring	Sample	Water Content	Liquid Limit	Plasticity Index
GBA-3	S-8	112.0		
	S-9	115.6		
	S-10	110.2		
	S-11	105.0		
	S-12	111.7		
	S-13	97.6		
	S-14	105.9		
	S-15	86.0		
	S-16	83.5		
GBA-4	S-1	281.5		
	S-2	130.5		
	S-3	119.6		
	S-4	112.1	99	61
	S-5	123.9	120	81
	S-6	109.4	101	63
	S-7	117.8		
	S-8	115.5	121	75
	S-9	106.7		
	S-10	109.8		
	S-11	112.3		
	S-12	112.6		
	S-13	109.1		
	S-14	106.8		

Earth Engineering & Sciences, Inc.

CONSOLIDATION TEST

PREPARED BY:	DATE:	CHECKED BY:	DATE:		JOB NO.:
A.E. Myers	11-5-92	S.N. Gupta	11-6-92		92-199



PRESSURE VS. VOID-RATIO CURVES

BORING: GBA-3 SAMPLE: U-1

DEPTH: 24.5'-26.5'

MATERIAL: Gray silty clay, trace shells

MOISTURE CONTENT: 117.3

UNIT WET WEIGHT: 86 pcf

UNIT DRY WEIGHT: 39.9 pcf

SPECIFIC GRAVITY: 2.45

APPENDIX B

ENVIRONMENTAL CONCERN Inc.
REPORT

ENVIRONMENTAL
CONCERN

4 October 1991

Richard Thomas
Gahagan & Bryant Associates, Inc.
Candler Building, Suite 1001
111 Market Street
Baltimore, MD 21202-4012

RE: Bethlehem Steel Shoreline Enhancement Prefeasibility Analysis

Dear Mr. Thomas:

Below please find the comments from Environmental Concern Inc. (EC) regarding the above referenced project.

1) Generally, EC does not recommend trying to create a marsh when the fetch is greater than one mile, unless a breakwall is created to reduce wave energy. This is because as a marsh develops it builds up a peat bank which will eventually be eroded by the wave energy. The fetch at the Bethlehem Steel site is much greater than one mile. Therefore the containment dike for the dredge material will have to be designed in such a way as to provide a permanent wave break for the constructed marsh.

2) The dike/breakwall must be constructed in such a way as to insure that tidal flushing in the created marsh is not restricted (i.e. that the tidal range and duration inside the dike/breakwall area is the same as the outside of this area).

3) The conceptual plan calls for grades of approximately 1:1,000. This slope is fine for marsh establishment if the site positively drains. Depressions in the marsh surface that do not drain at low tide will not support long-term plant growth. Establishment of tidal creeks (drainage channels) throughout the site may be warranted to facilitate drainage.

P.O. Box P, ST. Michaels, Maryland 21663 | (410) 745-9620

4) Apparently the dredge material is predominantly fine materials (silts and clays). When these types of materials are hydraulically dredged, they tend to settle slowly and remain unconsolidated and poorly drained for long periods of time under tidal conditions. When these sediments are unconsolidated they will support plant material during the growing season. However, insufficient oxygen levels in the unconsolidated sediments generally lead to plant mortality during plant dormancy. Therefore, the sediments must be consolidated and well drained prior to marsh establishment. The experience of Environmental Concern Inc., with fine sediment disposal in the Chesapeake Bay, has been that consolidation of sediments, placed at or above mean high water, at dredge material disposal sites is generally less than 1/2 foot. If proper drainage is supplied (i.e. channels) planting can generally take place within a year.

5) Using the 1992 tide table for Fort Carroll, and assuming mean low water is 0.0' NGVD, it appears as if the tidal range at the site is approximately 1.1'. Saltmarsh cordgrass (Spartina alterniflora) low marsh can be established from approximately the mid-tide (MT) elevation up to mean high water (MHW) if peat potted plants are used. If the site is seeded, then low marsh can only be established in the upper one third of the area between mean low water (MLW) and MHW. Therefore, low marsh can be established at elevations from +0.55' to +1.1' using peat potted stock. If the site is seeded, low marsh can be established from +0.73' to +1.1'.

6) Salt hay (Spartina patens) high marsh can be established from MHW to about 2.5' above MHW. Therefore, the high marsh can be established at approximately +1.1' to + 3.6'.

7) The conceptual plan also calls for an upland berm and buffer plantings. Dredge material composed of fine sediment particles often must be amended before it is suitable for upland plantings. Soil amendments may be needed for several reasons. Frequently salt content in dredge material is of high enough levels to inhibit plant growth. Therefore it may be necessary to leach the salts out of the material prior to using it as a planting medium. Dredge material also tends to have sulfidic materials associated with it and could become acidic upon exposure to air. Additionally, this material tends to compact easily, promoting water runoff instead of infiltration into the sediment.

8) Although the elevations listed above for marsh establishment are good guidelines for prefeasibility analysis, prior to final marsh design biological benchmark data must be collected. A biological benchmark is the elevation at which given plant species or communities are growing within a local area. Under tidal conditions, the biological benchmarks will reflect the local hydrology (tidal cycle), which dictates the zonation of the plant communities. By replicating the biological benchmark elevations at

the wetland creation site, the designer can be assured that the proper hydrology will be established at the site when it is connected to the tides. Black Marsh near North Point, and the marshes around Rock Hall on the Eastern Shore are likely candidates for collecting biological benchmark data.

9) The collection of biological benchmark data at this point in time is not necessary. Since it is anticipated that marsh construction will not take place for another 15+ years, biological benckmark data should be collected immediately prior to final marsh design. This is because sea level rise may alter biological benchmark elevations in the years prior to marsh construction.

10) From a regulatory perspective, it may be desireable to construct the project in cells. Using this method, a cell can be filled, consolidated and planted in a shorter time than if the project was one large cell. By constructing the project in cells, marsh establishment can take place concurrently with the filling of subsequent cells, thus providing mitigation earlier in the process. This may be a prefered alternative of the regulatory agencies. Therefore, it may be advisable, during the prefeasibility analysis, to consider the project ramifications of constructing the project in cells.

11) For preliminary budget estimates, the cost for supplying materials and labor to plant a cordgrass marsh is in the range of $15,000 an acre (1992 dollars). Seeding the site is approximately $3,000 an acre (1992 dollars). A combination of planting and seeding in the marsh portion of the project should be anticipated.

12) For preliminary budget estimates, upland habitat (buffer) plantings will cost approximately $18,000 per acre (1992 dollars).

13) The preliminary budget should also include money for yearly site maintenance. Common reed (Phragmites australis) control, dike repair and debris removal may be needed.

14) If it is assumed that half of the 300 acre wetland creation site can be seeded, and the remainder planted using peat potted stock (2' on center), then approximately 1,600,000 peat potted plants and 65,340,000 pure live seeds will be needed. It will probably be impossible to find this many nursery supplied plants and seeds on the entire East Coast. Generally the maximum amount of seed available is enough to plant 50 acres. To get this amount of seed, an order must be placed a year or more in advance.

Although it is possible to get 1,600,000 peat potted plants, they must be ordered well in advance of the planting date and contract grown. Provisions for phased planting and/or contract growing of the needed plants and collection of the seeds must be planned.

If you have any questions pertaining to this report please do not hesitate to contact me.

Sincerely,

Mark L. Kraus

Mark L. Kraus, Ph.D.
Senior Associate

APPENDIX C

COST SUMMARY
HYDRAULIC DREDGE, SAND DIKE OPTION

11/05/92

COST SUMMARY
27" HYDRAULIC DREDGE WITH SPIDER BARGE, HOPPER SCOWS AND HYDRAULIC UNLOADER

Mobilization and Demobilization						$ 233,000
Operating Costs						
1	Hydraulic Dredge	1.09	Months @ $	582,407	634,824	
1	Hyd. Unloader	1.09	Months @ $	363,518	396,235	
3	Towing Tug	1.09	Months @ $	187,772	614,014	
2	Tending Tug	1.09	Months @ $	59,599	129,926	
1	Survey/Crewboat	1.09	Months @ $	53,234	58,025	
6	Hopper Scows	1.09	Months @ $	5,488	35,892	
1	Derrick Barge	1.09	Months @ $	105,441	114,931	
1	Spider Barge	1.09	Months @ $	73,189	79,776	
1	Fuel Barge	1.09	Months @ $	2,938	3,202	
1	Deck Barge	1.09	Months @ $	1,969	2,146	
1	Shore Crew	1.09	Months @ $	242,677	264,518	
1	Superv/Engrg	1.09	Months @ $	56,027	61,069	

				Total Operating Costs	$	2,394,558
Ownership Costs						
1	Hydraulic Dredge	1.09	Months @ $	255,693	278,705	
1	Hyd. Unloader	1.09	Months @ $	139,559	152,119	
3	Towing Tug	1.09	Months @ $	75,547	247,039	
2	Tending Tug	1.09	Months @ $	12,248	26,701	
1	Survey/Crewboat	1.09	Months @ $	8,252	8,995	
6	Hopper Scows	1.09	Months @ $	25,214	164,900	
1	Derrick Barge	1.09	Months @ $	13,929	15,183	
1	Spider Barge	1.09	Months @ $	27,456	29,927	
1	Fuel Barge	1.09	Months @ $	14,591	15,904	
1	Deck Barge	1.09	Months @ $	7,503	8,178	

			Total Ownership Costs	$	947,650	

Market Factor @ 100 %			947,650

	Total Direct Costs	$	3,342,208
Overhead @ 15 %			501,331

	Sub Total	$	3,843,539
Contingency @ 10 %			384,354
Profit @ 15 %			576,531

	Sub Total	$	4,804,424
Bond @ 0.5 %			24,022

	Total Dredge Price	$	4,828,446
			==========
	Anticipated Contractor's Price	$	5,061,446

$$\frac{4{,}828{,}446 \text{ Dredge Price \$}}{435{,}000 \text{ Pay Cubic Yards}} = 11.10 \text{ \$/CY}$$

COST SUMMARY
27" HYDRAULIC DREDGE WITH SPIDER BARGE, HOPPER SCOWS AND HYDRAULIC UNLOADER

Mobilization and Demobilization						$ 233,000
Operating Costs						
1	Hydraulic Dredge	1.42	Months @ $	582,407	827,018	
1	Hyd. Unloader	1.42	Months @ $	363,518	516,196	
3	Towing Tug	1.42	Months @ $	187,772	799,909	
2	Tending Tug	1.42	Months @ $	59,599	169,261	
1	Survey/Crewboat	1.42	Months @ $	53,234	75,592	
6	Hopper Scows	1.42	Months @ $	5,488	46,758	
1	Derrick Barge	1.42	Months @ $	105,441	149,726	
1	Spider Barge	1.42	Months @ $	73,189	103,928	
1	Fuel Barge	1.42	Months @ $	2,938	4,172	
1	Deck Barge	1.42	Months @ $	1,969	2,796	
1	Shore Crew	1.42	Months @ $	242,677	344,601	
1	Superv/Engrg	1.42	Months @ $	56,027	79,558	
					Total Operating Costs $	3,119,516
Ownership Costs						
1	Hydraulic Dredge	1.42	Months @ $	255,693	363,084	
1	Hyd. Unloader	1.42	Months @ $	139,559	198,174	
3	Towing Tug	1.42	Months @ $	75,547	321,830	
2	Tending Tug	1.42	Months @ $	12,248	34,784	
1	Survey/Crewboat	1.42	Months @ $	8,252	11,718	
6	Hopper Scows	1.42	Months @ $	25,214	214,823	
1	Derrick Barge	1.42	Months @ $	13,929	19,779	
1	Spider Barge	1.42	Months @ $	27,456	38,988	
1	Fuel Barge	1.42	Months @ $	14,591	20,719	
1	Deck Barge	1.42	Months @ $	7,503	10,654	
				Total Ownership Costs $	1,234,554	

Market Factor @ 100 %		1,234,554	
	Total Direct Costs $	4,354,069	
Overhead @ 15 %		653,110	
	Sub Total $	5,007,180	
Contingency @ 10 %		500,718	
Profit @ 15 %		751,077	
	Sub Total $	6,258,975	
Bond @ 0.5 %		31,295	
	Total Dredge Price $		6,290,270
	Anticipated Contractor's Price	$	6,523,270

$$\frac{6{,}290{,}270 \text{ Dredge Price \$}}{568{,}000 \text{ Pay Cubic Yards}} = 11.07 \text{ \$/CY}$$

Bethlehem Steel

11/05/92

COST SUMMARY

27" HYDRAULIC DREDGE WITH SPIDER BARGE, HOPPER SCOWS AND HYDRAULIC UNLOADER

Mobilization and Demobilization						$	233,000
Operating Costs							
1	Hydraulic Dredge	1.62	Months @ $	582,407	943,499		
1	Hyd. Unloader	1.62	Months @ $	363,518	588,899		
3	Towing Tug	1.62	Months @ $	187,772	912,572		
2	Tending Tug	1.62	Months @ $	59,599	193,101		
1	Survey/Crewboat	1.62	Months @ $	53,234	86,239		
6	Hopper Scows	1.62	Months @ $	5,488	53,343		
1	Derrick Barge	1.62	Months @ $	105,441	170,814		
1	Spider Barge	1.62	Months @ $	73,189	118,566		
1	Fuel Barge	1.62	Months @ $	2,938	4,760		
1	Deck Barge	1.62	Months @ $	1,969	3,190		
1	Shore Crew	1.62	Months @ $	242,677	393,137		
1	Superv/Engrg	1.62	Months @ $	56,027	90,764		
				Total Operating Costs	$	3,558,884	
Ownership Costs							
1	Hydraulic Dredge	1.62	Months @ $	255,693	414,223		
1	Hyd. Unloader	1.62	Months @ $	139,559	226,086		
3	Towing Tug	1.62	Months @ $	75,547	367,158		
2	Tending Tug	1.62	Months @ $	12,248	39,684		
1	Survey/Crewboat	1.62	Months @ $	8,252	13,368		
6	Hopper Scows	1.62	Months @ $	25,214	245,080		
1	Derrick Barge	1.62	Months @ $	13,929	22,565		
1	Spider Barge	1.62	Months @ $	27,456	44,479		
1	Fuel Barge	1.62	Months @ $	14,591	23,637		
1	Deck Barge	1.62	Months @ $	7,503	12,155		
			Total Ownership Costs	$	1,408,434		
Market Factor @ 100 %						1,408,434	
				Total Direct Costs	$	4,967,319	
Overhead @ 15 %						745,098	
				Sub Total	$	5,712,416	
Contingency @ 10 %						571,242	
Profit @ 15 %						856,862	
				Sub Total	$	7,140,520	
Bond @ 0.5 %						35,703	
				Total Dredge Price	$		7,176,223
				Anticipated Contractor's Price		$	7,409,223

$$\frac{7{,}176{,}223 \text{ Dredge Price \$}}{668{,}000 \text{ Pay Cubic Yards}} = 10.74 \text{ \$/CY}$$

Bethlehem Steel

APPENDIX D

GEOFABRIC SELECTION AND COSTS

FABRIC SELECTION

After conversations with Dov Leshinsky PhD of the University of Delaware and Tom Collins of Huesker Inc., the fabric specified in the enclosures appears well suited to the proposed application. The Tensile strength of 1200#/inch in both directions and seam strength of 550#/inch may be slightly conservative. When more definitive soil data is available, a reduction in strength and in cost is probable.

Indeed, the price offered for this material may be 10-12% lower if the project moved beyond the conceptual stage.

INSTALLATION IN 14 FEET OF WATER

Projected method-Method used by American Dredging at Wilmington South project i.e. sew seams on a barge and allow fabric to play off into the water as barge backs up.

Equipment required with 6:1 dike side slopes:

1) Car float barge - 300'x 40'x 8' (non-ABS) Rental	$5,000/month
2) Sewing machine Purchase, mount, fabricate	$15,000 LS
3) 2 - 350 hp tugs 2-3 day/week Rental - $450/day/ea-2(450)30=	$27,000/month
4) Misc. supplies-torches, oil, fuel, grease, etc. + testing + sampling - $200/ea(100)=	$25,000 LS
5) 2 large barge winches Rental - 2($5000/ea/mo.) +	$10,000/month
6) Mobilization - mount rollers, winches, tuggers generator on barge	$100,000 LS
7) 4 - 1500# anchors =	$8,000 LS
8) 20 - 150# anchors =	$6,000 LS
9) Floating winches to secure fabric sides Rental @ $100/day/ea = 2(100)30 + move fabric	$6,000/month
Monthly Rate =	$48,000/month
Lump sum all mobilization =	$154,000

Crew	
Barge Crew	
Foreman @ $1000/week all costs (4.33) =	$4,333/month
1 Mate @ $250/day (6 days/week) 4.33 =	$6,495/month
4 deckhands @ 4 (225/day)6(4.33) =	$23,382/month
2 Masters + 2 boat deckhands	
2(250)+2(225)/day (6 days) 4.33 =	$24,681/month
Project Engineer =	$5,000/month
Quality Control =	$5,000/month
Total Payroll =	$68,891/month

TIME ESTIMATE

Looming lead time = 3 months
Fabric width = 16', use 60' pieces on barge
Placement in 200' increments - 2 days/placement - 1 day for placement and 1 day to prepare and secure.

10,600'/200 = 53 placements; 53(2 days/placement) = 106 days

Field seaming - 180 seams/3 seams/day production = 60 days

Total length = 10,000 ft. + 600 ft. for overlaps

Fabric surface area (allow 10 ft. on either side of dike) =
10,000(285')/9 + 300(300)/9 = 336,666 sy

Sewing and placement = 106 + 60 = 165 days
Use 6 months for conceptual estimate

ESTIMATE

Equipment - $48,000/month (6 months) =	$288,000
Mobilization =	$154,000
Labor - $68,800/month (6 months) =	$412,800
Weather and contingencies - 20% =	$119,000
Profit - 15%	$126,360
Total Fabric Installation =	**$1,099,360**

Fabric furnished to site @ $7.25/sy =
$7.25/sy(336,666 sy) = **$2,440,825**

Total Installed Fabric Estimate = **$3,540,189**

Estimate = **$10.51/sy**

In addition to the approximately 1,200,000 cy of borrow volume, the 340,000 sy of fabric, and the 400,000 cy of upland dike volume, the dike must be protected with rip rap. The projected volume would be applied to 9,800 lf at a slope of 6:1, for a height of 4 ft. vertically and a 2 ft. thickness. This yields a volume of 175,000 cy. Local supply and competitively priced placement should present no problems as there are a number of quarries and competent rip rap contractors in the vicinity.